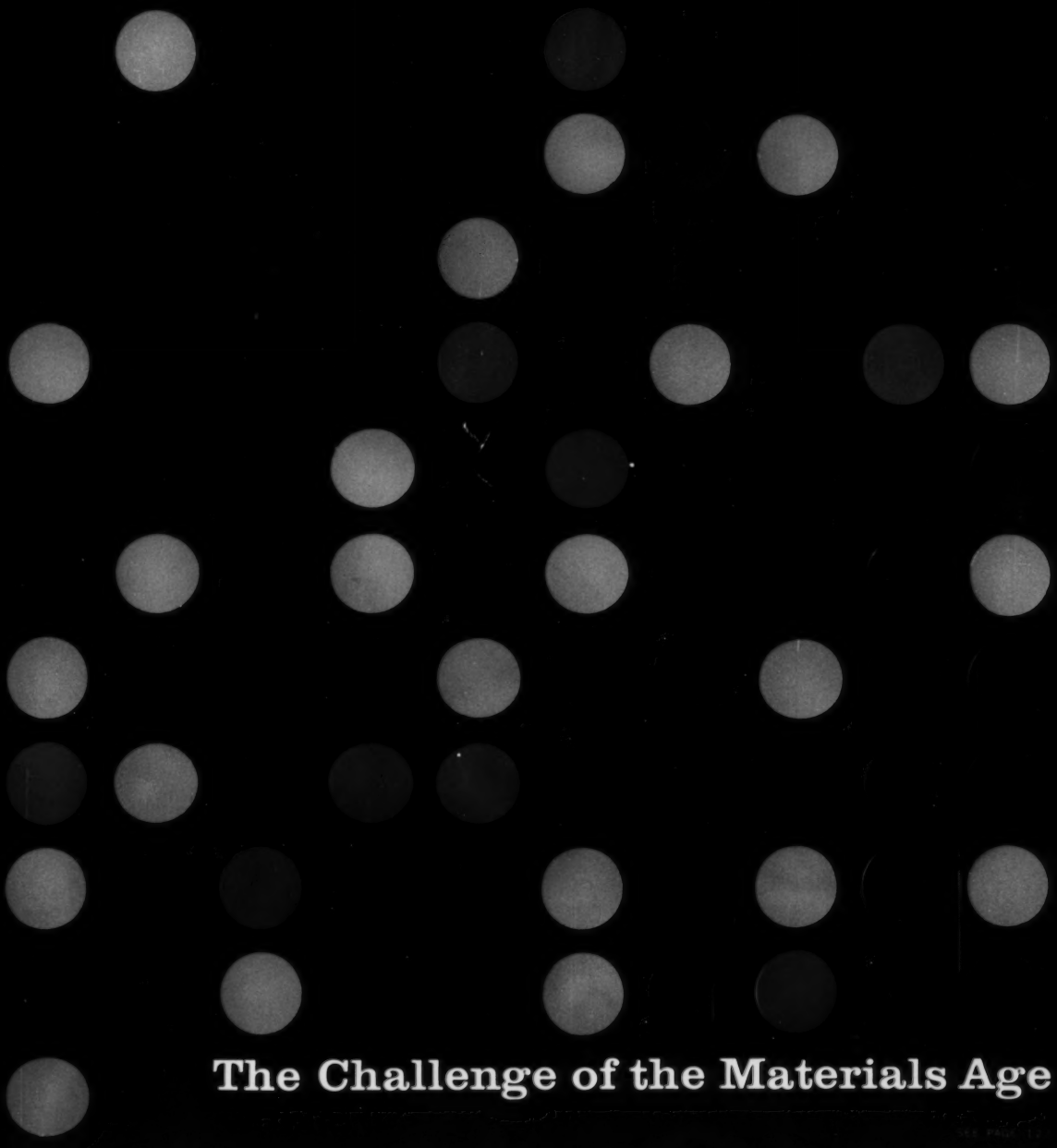
Materials
in Design Engineering



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SEPTEMBER, 1960 | VOL. 52, NO. 3

Materials in Design Engineering

FORMERLY MATERIALS & METHODS

APPLICATION OF METALS, NONMETALLICS, FORMS, FINISHES

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COVER AND SPECIAL REPORT DESIGNED BY HARRY & MARION ZELENKO

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Materials for Portable Research Reactors
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Six Nonmilitary Uses of Titanium
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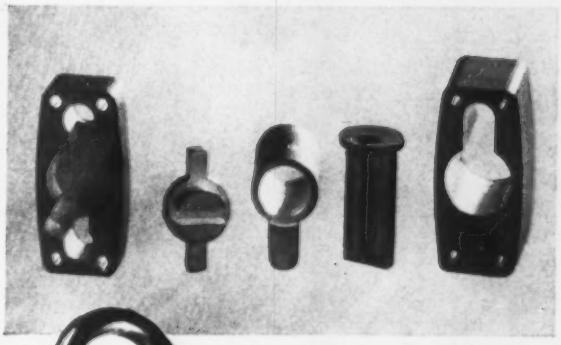

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Made to military specifications by Reese Padlock Company, this new dead-bolt padlock is built almost entirely of brass powder parts.*

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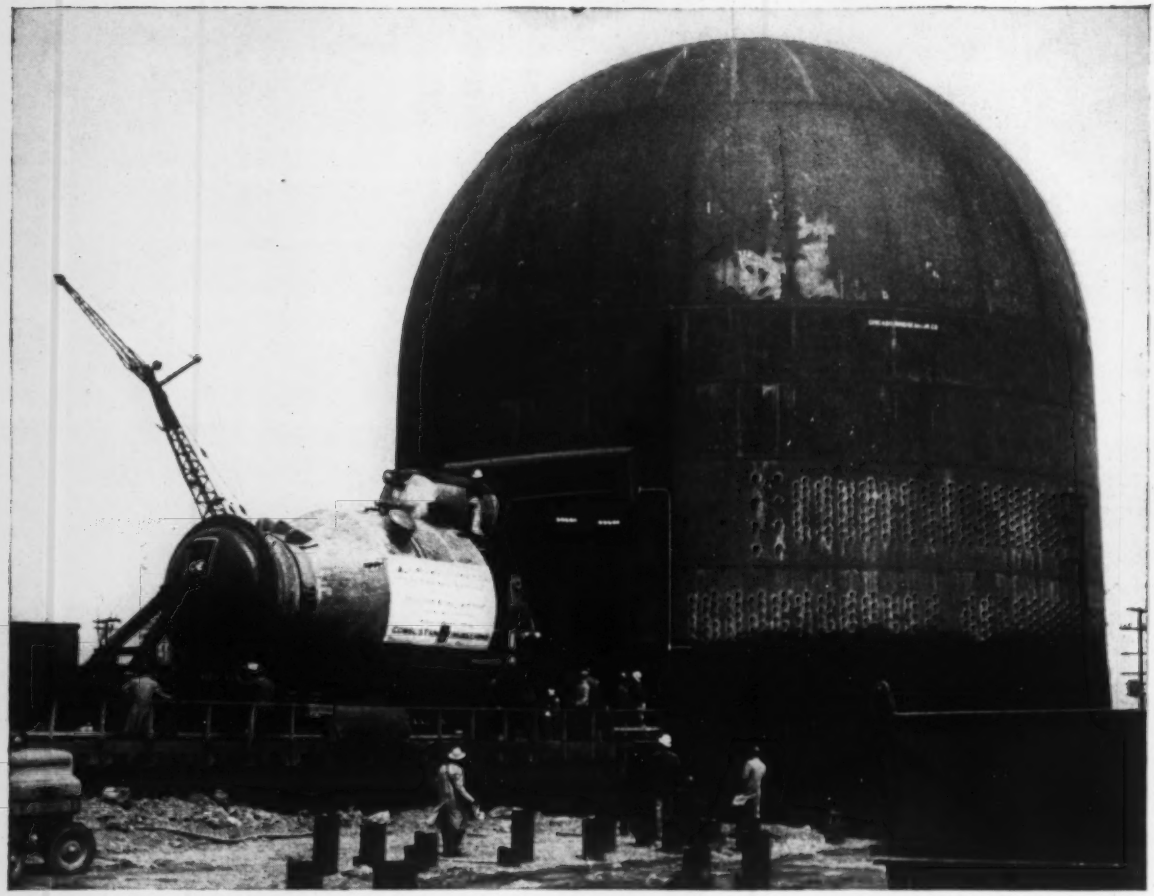

Atoms for Peace. This dome houses the 91-ton reactor vessel made of nickel-containing stainless steel for the new Enrico Fermi Atomic Power Plant on the shore of Lake Erie near Monroe, Michigan. Detail design and construction of the reactor vessel was done by Combustion Engineering, Inc. Plant will be built and operated by Power Reactor Development Company from designs supplied by Atomic Power Development Associates, Inc.

Atomic reactor "breeds" its own fuel

Stainless steel vessel must withstand high temperatures and corrosives

The world's largest full-scale nuclear reactor of the "fast-breeder" type is now being built. It may well answer the question:

> *When will atomic power be competitive with conventional methods of producing electric power?*

As the term "fast-breeder" indicates, the atom-splitting process is maintained by so-called *fast* or high-energy particles. It produces more nuclear fuel than it consumes. The fast-breeder actually turns out a kilogram and a fifth of new fuel for each kilogram it burns up!

The "breeding" takes place in a 36-foot high pressure vessel. Here, the high-energy particles (neutrons) travel at speeds of thousands of miles per second to keep the atom-splitting chain reaction going.

Accent on safety. A major objective was to make this reactor vessel safe. That called for a lot of highly specialized work.

It also called for a rugged metal: one capable of withstanding the tremendous heat given off in nuclear fission, and of bearing up under the temperatures and corrosives encountered. The final choice? Strong, corrosion-resisting Type 304 stainless steel. It's a stainless steel that contains Nickel – one of the big reasons for these superior properties.

How to "fast-breed" ideas. Problems involving reactor materials may never be a concern of yours. But you can run into *metal selection problems* involving corrosion, pressures, high temperatures and other destructive conditions almost any time. When you do, remember there is a good chance that a steel containing Nickel will provide the properties you want. Let us help you find out.

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What's new IN MATERIALS

...AT A GLANCE

A new film-forming and moldable dielectric material—cyanoethylated cellulose—is claimed to have the highest dielectric constant (12.5) of all known film-forming materials. First commercial use for the new material will be in an electroluminescent lamp. Initial price of the developmental product is $27 per lb. (More details in a forthcoming issue.)

Source: American Cyanamid Co., 30 Rockefeller Plaza, New York 20.

New vanadium-base alloys containing 20 to 50% columbium show good high temperature strength, good corrosion resistance in both oxidizing and reducing atmospheres, and good fabricability by conventional hot working techniques in air. The alloys, still under development, are designed for use in high temperature applications where good strength-to-weight ratio is required.

Source: S. T. Wlodek, Union Carbide Metals Co., Div. of Union Carbide Corp., 30 E. 42nd St., New York 17.

High purity silicon is now available in polycrystalline rod form. The producer says the new product can be zone refined to single-crystal silicon for use in power rectifiers, transistors, diodes and other semiconductor devices. The material sells for about $300 per lb.

Source: Dow Corning Corp., Midland, Mich.

Two new semiconductor-grade materials—cadmium telluride and magnesium oxide—are now on the market. The cadmium telluride is supplied in polycrystalline form and the magnesium oxide in single crystal whiskers ranging from 3 to 4 mm in length.

Source: Semi-Elements, Inc., Saxonburg Blvd., Saxonburg, Pa.

A high strength, corrosion resistant copper alloy for use in electrical and other equipment is now available in the form of round rod. The alloy contains 97.50% copper, 1.9% nickel and 0.6% silicon. The developer says that most of the nickel and silicon in the heat treated alloy are present as an intermetallic compound of nickel silicide, and that it is the precipitation of nickel silicide in the form of submicroscopic particles by a low temperature heat treatment that accounts for the distinctive properties of the alloy.

Source: American Brass Co., Waterbury, Conn.

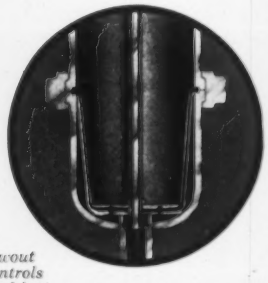
A new high temperature plastics molding compound, a mineral-filled silicone, offers long-term stability at 700 F and excellent thermal shock resistance over the range −67 to 500 F. Its extremely low dissipation factor (0.0006 at 10^6 cps) and high arc resistance make it very promising for high temperature electrical insulation. An additional feature is retention of dimensions at temperatures above 2500 F, although at such temperatures the material is highly porous. (More details next month.)

Source: Dow Corning Corp., Midland, Mich.

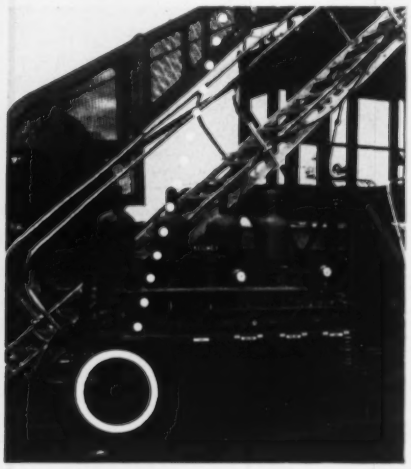
A carbon steel wire with 575,000 psi tensile strength is now available in commercial quantities (see M/DE, Aug '60, p 133). The developer says this strength

Another new development using

B.F.Goodrich Chemical *raw materials*



Koomey blowout preventer controls manufactured by Stewart & Stevenson Distributing Company, Houston, use bladders made of Hycar by Oteco Equipment Company, Houston. B.F.Goodrich Chemical Company supplies the Hycar nitrile rubber.



500,000 cycles prove toughness of Hycar accumulator bladder

Before the bladder made of Hycar nitrile rubber shown above was approved for use in accumulators like the one in the background, it was tested for more than half a million cycles under highest pressures—with no signs of failure.

The toughness and resilience that even 500,000 cycles can't affect is only one advantage provided by Hycar. Its unusual ability to resist deterioration provides longer, surer, safer operation for this and other oil field equipment. Hycar resists chemicals, oils and solvents that destroy ordinary rubber.

Here's another example of why it pays to specify Hycar everywhere in oil fields. For more information, write Dept. FN-5, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

Hycar

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exceeds that of any carbon steel wire now on the market. A potential use for the wire is as a reinforcement in high strength plastics parts. The wire is supplied in 0.005-in. dia with a brass finish.

Source: National-Standard Co., 601 N. 8th St., Niles, Mich.

Flexible films of polystyrene foam will compete with paper in many types of packaging and displays, two producers say. In addition to being waterproof, lightweight, non-abrasive and grease resistant, the films provide thermal insulation and shock absorption. They can be thermoformed to depth-diameter ratios of about 2:1.

Sources: Monsanto Chemical Co., Plastics Div., Springfield, Mass., and Dyna-Foam Corp., Ellenville, N. Y.

A new explanation for the rusting of iron says that hydrogen ions from water vapor penetrate iron and enlarge the sites at which oxygen normally combines with the metal. The reaction produces blade-shaped platelets of iron oxide on the surface of the metal, causing it to rust destructively. Until now, a standard explanation attributed iron corrosion to an electrochemical reaction. (More details in a forthcoming issue.)

Source: E. A. Gulbransen, Westinghouse Electric Corp., Box 2278, Pittsburgh 30.

Epoxies with increased flexibility and toughness at no sacrifice in electrical or mechanical properties can be obtained by using new, light colored, low viscosity liquid epoxy resins. They can be blended with conventional solid and liquid epoxies and are expected to be used in castings, adhesives, coatings and laminates.

Source: Dow Chemical Co., Midland, Mich.

A new nitride-bonded silicon carbide shows promise as a low cost structural material for linings in aluminum melting furnaces, rocket nozzles, blast pads at launching sites, and kiln fixtures. Although price of the material has not been revealed, the developer says it will cost considerably less than other nitride-bonded silicon carbides now on the market. The material has high thermal conductivity, good heat shock properties, and good resistance to most corrosive liquids.

Source: Norton Co., Refractories Div., Worcester 6, Mass.

Better and more economical columbium parts may result from a new fabricating technique in which cast structures of the metal are broken down by upset forging at 1000 F. The developer says atmospheric contamination is scarcely a problem at this temperature. Once the cast structures are broken down, the metal can be worked at room temperature.

Source: J. A. DeMastry, Battelle Memorial Inst., 505 King Ave., Columbus 1, Ohio.

New plastics films with low moisture absorption are now available in pilot plant quantities. The films are based on fluorohalocarbon resins. The producer says a polyester film would have to be over 700 times as thick and a polyethylene film over 400 times as thick as the new films to get the same moisture barrier benefits. The new films are said to be flexible over the temperature range −320 to 390 F. They are expected to be used for packaging electronic and other delicate equipment, drugs and chemicals.

Source: Allied Chemical Corp., General Chemical Div., 40 Rector St., New York 6.

Turn to page 9 for more "What's New in Materials"

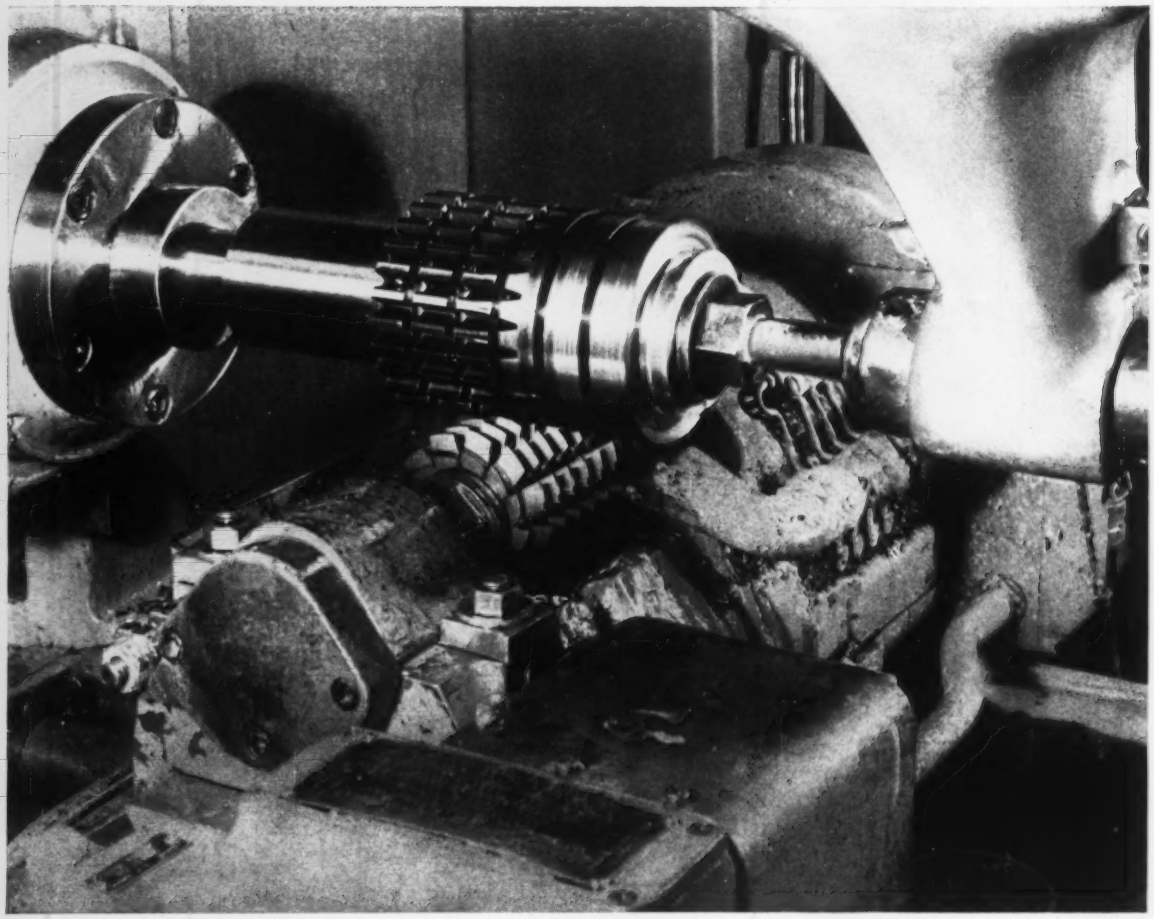

Photo courtesy Chelsea Products, Inc.

Aristoloy Leaded Steel provides free machining for Chelsea Products, Inc.

Steel for gears used in power take-off assemblies must have uniform hard surface, high tensile strength and yet machine freely. Aristoloy Leaded* users have benefited from these qualities.

Chelsea finds more gears can be cut from leaded Aristoloy before the hob needs sharpening. Production can be improved and speeds and feeds increased over non-leaded steel.

Strength and hardness are not affected and the finished part reveals no detectable difference in physical properties from steel previously used.

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For more information, turn to Reader Service card, circle No. 351

Low Friction Coating Works Best at 600-1200 F

Lead monoxide provides high temperature bearing surface

■ A new bearing development makes use of the lubricating properties of lead monoxide (PbO) to provide a low friction coating which can function from room temperature up to 1250 F. Lead monoxide coatings were developed at the NASA Lewis Research Center, Cleveland.

Applied like porcelain enamel

Effective lead monoxide coatings of several compositions have been successfully applied, in the manner of porcelain enamels, to stainless steel (types 440C and 304) and to Inconel X. One of the better coatings, combining excellent adherence with low friction properties, contains about 5% silicon dioxide and 5% iron oxide absorbed from the steel during the firing operation.

The coatings are applied as a dry powder or sprayed on as a water slurry, then fired in the range 1650 F to 1800 F. Such fired-on films provide lower friction coefficients at temperatures exceeding 600 F than commercial resin-bonded molybdenum disulfide coatings (see Fig 1).

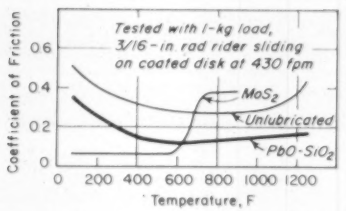
High temperatures help

Unlike conventional lubricating systems which function best when low surface temperatures are maintained at the bearing interface, the NASA coatings lubricate best under conditions that tend to promote high bearing surface temperatures, i.e., high ambient temperatures and high sliding velocities. At sliding velocities ranging from 2400 to 10,000 fpm (Fig 2) friction coefficients were within the range 0.05 to 0.08 at all temperatures studied.

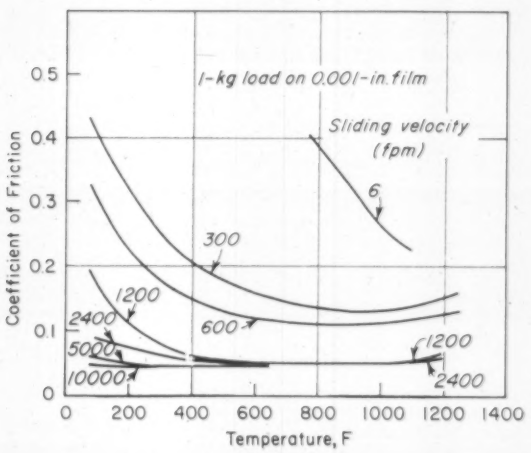
Reason for such performance is probably the formation of a glazed or vitreous surface promoted by the lead monoxide in the zone of sliding. Sliding then takes place by plastic or viscous shear rather than by shear along crystal planes.

Endurance life and temperature

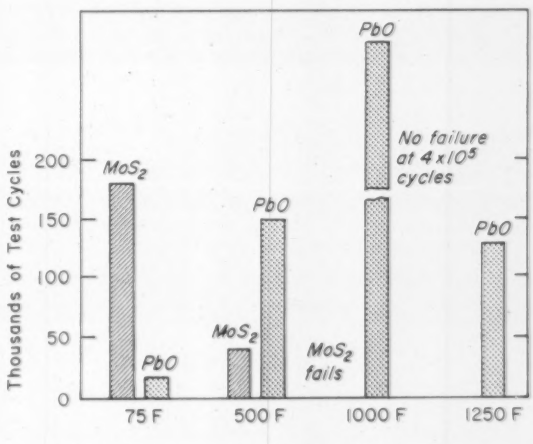
Endurance life of the lead monoxide coating seems to be sensitive to temperature, approaching a maximum at 1000 F, then decreasing slightly at 1250 F as shown in Fig 3. Although these coatings were designed to operate in the 600 to 1200 F range, the data show that both life expectancy and friction coefficient are good enough in cool operation to recommend them—even when the bearings must be started or cycled through room temperature.



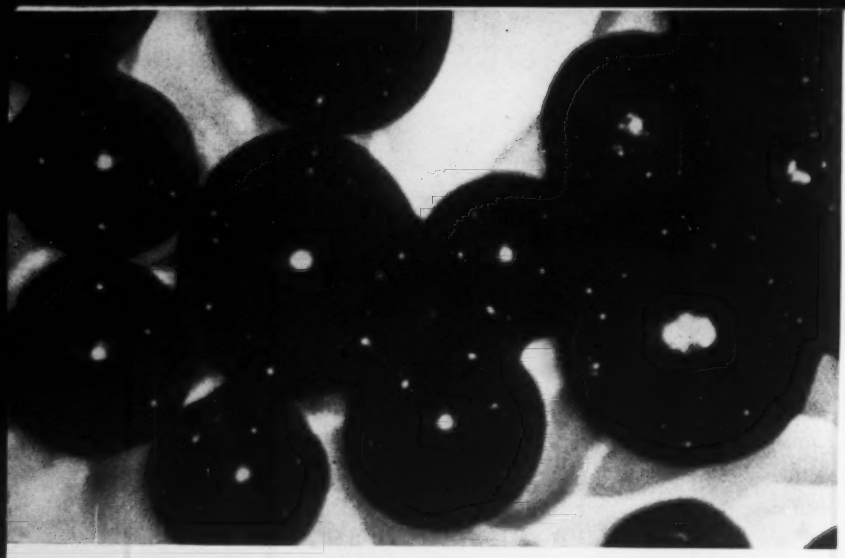
1—Effect of temperature on bearing lubricating properties.



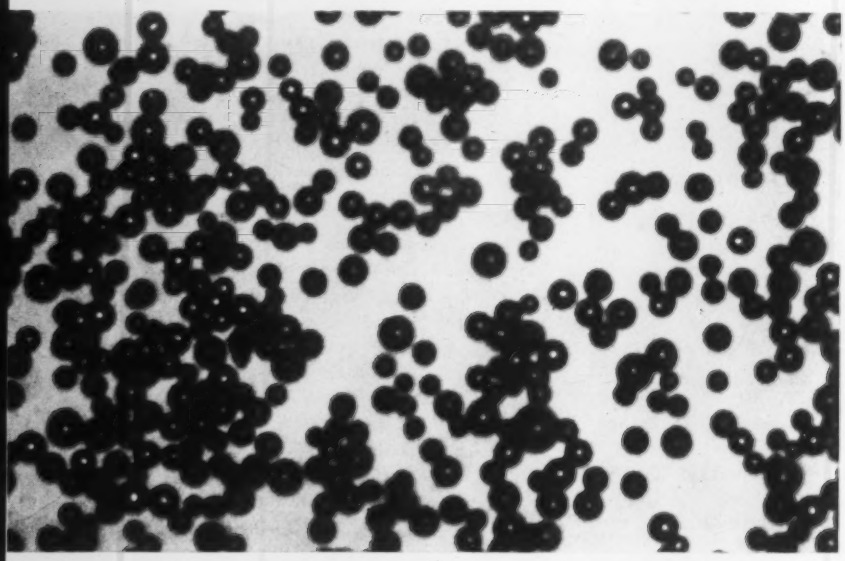
2—Effect of sliding velocity on lubricity of PbO-SiO_2 film.



3—How temperature affects life of lubricant coatings.



Spherical powders *of two metals at 100 magnifications. Above—Tungsten particles ranging from 74 to 149 μ in dia. Below—Nickel particles ranging from 10 to 20 μ.*



Uniform, Spherical Powders of Metals and Alloys

promise controlled porosity, other processing advantages

■ A way of making spherical powders of metals and alloys, with uniform particle sizes ranging from 20 to 150 μ, has been developed by Linde Co., Div. of Union Carbide Corp., 270 Park Ave., New York 17.

Produced in a totally inert atmosphere, the powders are free of such defects as voids, cavities and inclusions. Particle size uniformity is claimed to be 98%.

Six materials available

Six different powders are already available in limited quantities from Linde's Crystal Products Dept.: copper, aluminum, nickel, type 316 stainless steel, tungsten and Nichrome. Other products will be added as requirements arise.

The accompanying photographs show the powders at 100 magnifications in two size ranges. A development program is now under way to produce particles below 20 μ in size.

Linde warns that because no attempt is presently being made to prevent oxidation during handling, storage and shipment, the new powders may contain varying degrees of surface oxidation. Handling in a completely inert atmosphere throughout has been accomplished, however, and is available whenever oxides cannot be tolerated.

The process

Specific processing details have not been released by Linde. It is known, however, that the starting material is 1/16-in. dia wire of uniform cross section that is free from surface impurities. The powders are produced in a completely inert atmosphere to maintain high purity in the finished powder. The only limiting factor is the purity of the available metals.

Potential applications

Powders of uniform spherical shape are expected to be useful in fabricating sintered bodies requiring controlled porosity. Typical products would be filters, burner plates, sweat-cooled nozzles, porous piston rings, etc.

Other possible applications:

1. To improve the flow of angular powder particles into molds, and to improve the quality of sintered parts. Spherical powders would be added in quantities of 10 to 20%.

2. To make highly reactive metals less hazardous to handle in powder form. Spherical powders have the lowest possible surface-to-volume ratio.

3. To improve the burning stability and reduce the handling sensitivity of solid fuel rocket propellants. Spherical aluminum powders would be used as additives.

For more information, circle No. 600

The ceramic shell process. Left—*Pattern plus gating system is immersed several times in slurry.* Center—*Patterns are stuccoed with finely divided refractory.* Right—*Shell is cast, using vacuum assist to insure sound, dense metal.*

Large, Intricate Investment Castings Now Feasible

New mold process makes possible castings weighing up to 100 lb

■ Arwood Corp., Groton, Conn., recently announced the development of a ceramic shell process that can turn out intricately shaped investment castings weighing up to 100 lb. Previous investment castings made in a solid mold were limited to a size easily held in the palm of the hand.

The large castings are now being made in actual production runs in virtually all castable alloys. Normal investment casting tolerances are maintained.

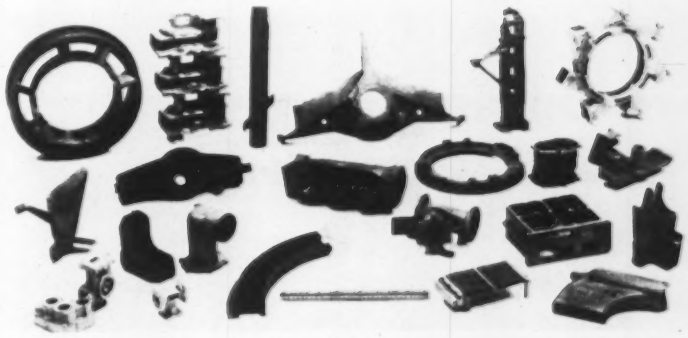
The lightweight shell mold, in comparison with the conventional solid mold, is what makes the larger castings possible. The mold is made by dipping a wax pattern repeatedly in a ceramic slurry to build up the shell, then firing the shell to strengthen it and melt out the wax. The conventional solid mold is made by investing the wax pattern in a flask filled with a ceramic composition.

The ceramic shell process, besides increasing casting size and weight from perhaps 50 lb max to 100 lb, also offers these other advantages:

1. It can produce parts with more intricate coring.
2. It can produce shapes that cannot be made by any other method.
3. It produces castings with a fine grain structure.
4. Less finishing is required than with ordinary solid mold castings.

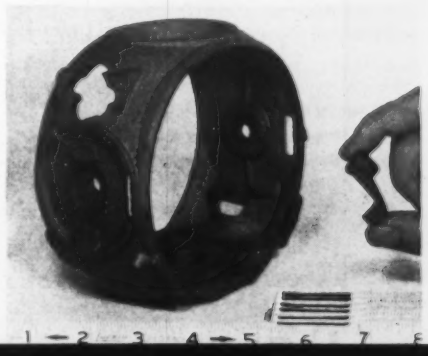
For more information, circle No. 601

Intricate contours *and complex shape, in addition to large size, are possible in ceramic shell investment casting.*

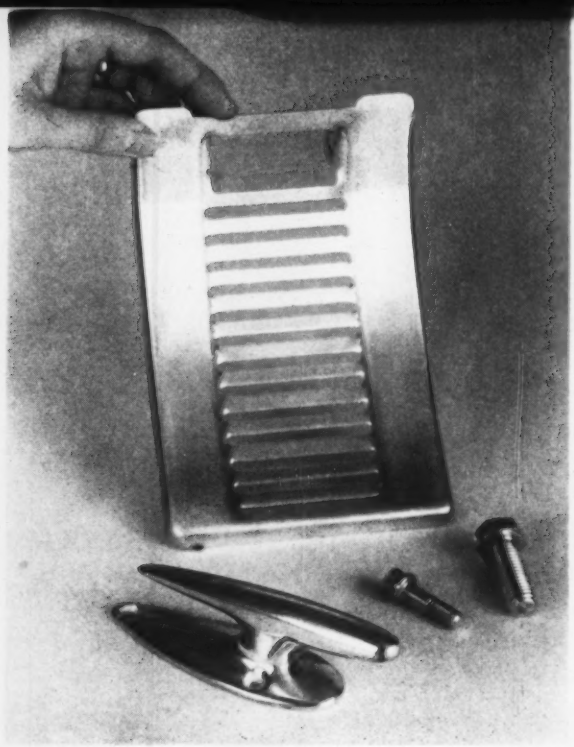


Variety of castings *produced by the ceramic shell method. Ruler at bottom center has 12-in. scale.*

Difference in size *between a typical investment casting and a large casting made possible by new mold process is evident here. Large part is component of a missile gyroscope cast in 17-4PH steel.*



Automobile bumper *protected with experimental heavy aluminum coating has been used for two years with no signs of corrosion.*



Typical parts *that can be coated with heavy aluminum deposits include stamped steel grills, cast iron cleat, and aircraft bolts of high tensile strength steel.*

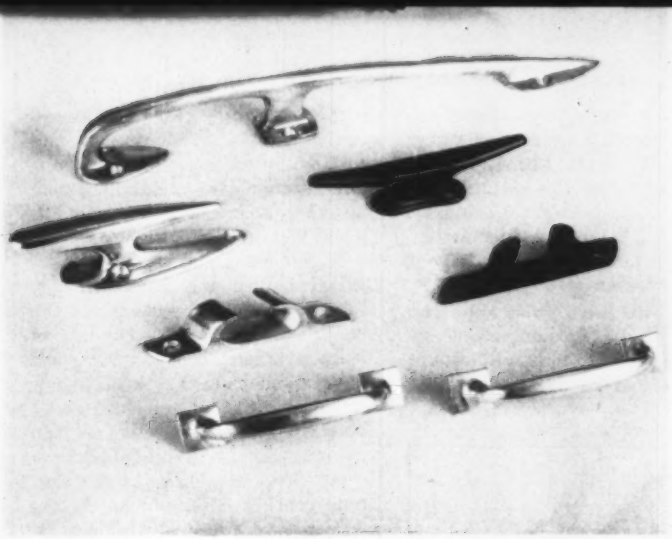
Thick Vacuum Metallized Coatings Are Durable, Corrosion Resistant

Now obtainable in thicknesses comparable to electroplates of other metals, they are pure, uniform, adherent and colorable.

by Philip J. Clough, *National Research Corp., and* **Howard M. Farrow,** *NRC Equipment Corp.*

■ Development of a new deposition technique now makes it possible to apply vacuum metallized coatings up to several mils thick, thereby opening up a host of new applications. Vacuum metallized coatings have been popular for many years because of their combination of excellent appearance and low cost. But because of their limited thickness (just a few millionths of an inch), the coatings have been limited mainly to decorative applications.

The new process (first announced in M/DE in Aug '59, p 132) provides coatings that often have better properties than electroplates and deposits materials that cannot be applied readily by other means. To date most of the development work has been confined to high purity aluminum and cadmium coatings. However, as pointed out elsewhere in this article, other materials can be deposited.



Various aluminum and iron castings *coated with aluminum. Dark castings have been anodized and dyed blue.*

Mild steel bolt *and notched tensile test specimen coated with cadmium are not affected by hydrogen embrittlement.*

Seven important advantages

1. High purity aluminum coatings can be applied

One of the most important advantages of the new process is that now high purity aluminum can be deposited in uniform, heavy thicknesses on a variety of base metals. Of course many techniques are available for depositing aluminum but they have limitations. No really commercially satisfactory method has been developed for electroplating aluminum. Sprayed aluminum requires post-heat treatment to obtain consolidation, it tends to be contaminated with oxides, and its thickness is difficult to control.

Finally, although hot dipping is fine for some uses, the high temperature involved may affect the temper of the steel part. Also, hot dipped coatings may be less pure than vacuum applied coatings because they tend to be contaminated with occluded salts from the flux used over the liquid metal.

2. Coatings can be anodized

An important feature of the aluminum coatings is that they can be anodized to provide a hard, wear resistant, aluminum oxide outer layer. Furthermore, if desired the coatings can be dyed in a wide variety of colors to increase their decorative appeal. Anodizing can be easily performed on coatings greater than $\frac{1}{2}$ mil thick.

Naturally, anodizing is not necessary in applications where just corrosion resistance is needed. In such cases, a simple oxide or chromate treatment can be used directly over the aluminum coating.

3. Coatings have good uniformity

Another significant advantage of heavy vacuum metallized coatings over electroplated coatings is that they are deposited uniformly and do not build up at edges and sharp points. Very recent developments have greatly improved the throwing power of vacuum

Where the Coatings Can Be Used

Because of the newness of heavy vacuum metallized coatings these are few commercial applications at present. As is to be expected, considerable development time is required because of the critical functions of the parts being evaluated. However, indications are that the coatings will meet expectations after suitable development testing. Following is a rundown of applications now under evaluation:

- Cadmium coatings for landing gear parts, high tensile strength bolts, pins, nuts and other fasteners.
- Miscellaneous automotive and appliance parts for decoration and corrision resistance.
- Aluminum die castings requiring better appearance or wear resistance. Coated castings are still in the development stage and are being evaluated by major die casting producers.
- Cast iron parts for marine applications.
- Aluminum coatings on high temperature, high tensile strength steel for miscellaneous aircraft and missile parts and fasteners.
- Aluminum coatings to prevent galvanic attack between dissimilar metals.
- Aluminum coatings on sheet steel for corrosion resistance and better appearance.

metallizing, and many hard-to-reach areas and deep-rooted threads can now be coated with reasonable uniformity. Aluminum for example, has been uniformly applied to the walls of blind holes as deep as five diameters.

The good reproducibility of heavy vacuum metallized coatings has been demonstrated in a series of tests on 4 × 6 in. panels. In shooting for a thickness of 0.3 mil, variations from panel to panel showed a thickness range between 0.4 to 0.8 mil. When desired thickness was 1 mil, the variation was between 0.7 and 1.1 mil. And at a desired thickness of 2 mils, the coatings varied from 1.8 to 2.6 mils.

4. Deposits have good adhesion

The good adhesion of heavy vacuum metallized aluminum coatings has been demonstrated by cementing two aluminum-coated panels to each other and testing in shear. Normally, the adhesive fails at about 2500 psi, although sometimes strength has been measured as high as 9000 psi. In all tests, the adhesive failed before the bond between the aluminum and steel. Thus, the shear strength of the bond is at least between 2500 and 9000 psi.

Good adhesion of the coatings has been further demonstrated by bending a coated steel panel 180 deg on itself in a vise. Whether in compression or tension, the aluminum coatings does not crack, except where the steel also cracks. Microscopic examination of the aluminum-steel interface shows no alloy formation and this accounts for the excellent ductility observed in the coating.

5. Process has no bad effects on base metals

Tensile and fatigue strength unaffected—Tests on aluminum-coated steel show that tensile strength is not affected by the coating process. For example, AISI 8740 steel tensile test bars heat treated to 190,000 psi yield retain this strength after being coated with 1 mil of aluminum. Furthermore, the aluminum shows good adhesion up to the yield point. Some spalling takes place after the yield point but this is insignificant as it occurs after the steel fails

Only limited data are available on the fatigue properties of aluminum-coated steel. However, preliminary results indicate that, outside of exhibiting a slightly narrower band of values, the fatigue limit of coated specimens is the same as for uncoated specimens.

Hydrogen embrittlement eliminated—Thick, vacuum-deposited cadmium coatings are currently being used in the aircraft industry to protect high tensile strength steel parts. These coatings have been used as a replacement for electroplates. Because of acidic materials used in electroplating, hydrogen can be introduced into the surface of steel parts. Since vacuum coatings essentially are deposited in the absence of impurities, no hydro-

Other Coatings Can Be Applied

Much of the development work on heavy vacuum metallized coatings has been confined to aluminum, primarily because a good background of experience exists with this metal and because it appears to have the best potential. However, due to important advances in vacuum technology, it now appears that many other useful types of coatings can be applied.

Oxides

As pointed out earlier, the surface of heavy (½ mil and up) aluminum coatings can be converted to aluminum oxide by anodizing. In addition, other metal oxide coatings can be obtained by using newly developed vacuum evaporation techniques in conjunction with an oxide conversion treatment. For example, chromium oxide coatings can be produced having high emissivity combined with high hardness and good abrasion resistance. Titanium dioxide and silicon dioxide coatings can also be deposited.

These coatings should be at least ¼ mil thick so that only the surface of the film is oxidized. If the film is so thin that the entire thickness must be oxidized then the film usually loses its adhesion to the substrate.

Carbides

Abrasion resistant tungsten carbide and silicon carbide coatings can be produced by a "semi-high" vacuum process, i.e., a process using less vacuum than ordinary evaporation processes. In this process tungsten or silicon is deposited in the presence of a hydrocarbon such as ethane or methane and forms the carbide directly. Alternatively, these coatings can be deposited by a two-step process in which the pure coatings are deposited first and then converted to carbides by diffusing carbon into the metal film.

Recent progress with electron guns for controlled electron bombardment of high melting point, low vapor pressure metals, provides good control over evaporation rates. Thus, thin or thick coatings of refractory metals can be applied with the density and uniformity characteristic of regular vacuum metallized coatings.

Tungsten

With a newly found means of evaporating tungsten it now seems possible to fabricate intricate shapes of pure tungsten. This would be done by evaporating tungsten onto a suitable reverse pattern which is subsequently melted away, thus leaving a tungsten part of the desired configuration.

Composite coatings

Vacuum evaporation can be used to produce thin or thick alloy coatings with varying degrees of reflectivity and emissivity. These coatings can be deposited by simultaneously evaporating two metals; or else by depositing the metals separately and then using a diffusion treatment to produce alloying. Alloy deposition has been used to produce thin, uniform layers of brazing alloys, and in applications where electrical properties must be controlled.

gen and, therefore, no hydrogen embrittlement, is introduced.

Heavy vacuum-deposited cadmium coatings are now covered in military specification MIL-C-8837 and many aircraft companies are currently using this specification for procurement. The specification calls for thicknesses ranging from 0.2 to 0.5 mil. It also specifies that no acidic materials be used during cleaning, degreasing, etc., prior to metallizing.

6. Aluminum protects well at high temperatures

Although vacuum-deposited cadmium coatings eliminate hydrogen embrittlement and prevent corrosion they are limited to a maximum operating temperature of about 500 F. At higher temperatures cadmium attacks steel base metals and causes rapid failure. (Also, the material is relatively soft and has poor abrasion and wear resistance.) This limitation can be overcome by vacuum coating parts with aluminum. Aluminum will withstand much higher temperatures than cadmium. Furthermore, vacuum-deposited aluminum coatings are superior to hot dipped aluminum coatings since vacuum deposits are cleaner and do not contain any slag or fluxes.

7. Coatings provide good corrosion resistance

Unlike the conventional thin coatings, heavy vacuum coatings provide excellent corrosion resistance. Using a military test that specifies 96 hr of resistance to 20% salt spray exposure, a 0.5 to 1-mil thick aluminum coating on high strength steel has been exposed for 600 hr before corrosion occurred. Coatings 2 mils thick have shown no attack after 1600 hr.

Following are some typical corrosion rates obtained by immersing aluminum coated panels in 3% sodium chloride at room temperature:

Base Metal	Corrosion Rate, mil/yr	
	Uncoated	Coated
8740 Steel	1.8	0.0096
Mild Steel	2.08	0.0029
Vascojet 1000	2.13	0.0042

Practical tests have also been made on aluminum coated automotive parts. An automobile bumper (see photo) has withstood over two years of driving, including exposure to corrosive salts and abrasive sand on icy highways without any evidence of corrosion.

Good results have also been obtained in stress corrosion tests conducted with aluminum coatings on tensile test specimens of 7075 aluminum stressed to 75% of their yield strength. Coated specimens showed an average life of 250 hr when immersed in a solution of sodium chloride, potassium dichromate and chromic acid. Uncoated specimens, in contrast, had average life of 24 hr.

How the coatings are applied

Base materials used

Much of the development with heavy coatings applied by the new evaporation method has been confined to aluminum coatings for special purpose steels such as 8740, H-11 and Vascojet. However, aluminum coatings have also been applied to cold rolled steel (including stampings), cast iron, titanium, and wrought and die cast aluminum and magnesium alloys. They cannot be used on zinc die castings.

The use of aluminum coatings over aluminum alloys is especially interesting and is similar in principle to alclad laminates. However, vacuum metallized coatings have an advantage in that they can be applied to complex shapes. Alloys such as 7075 and 2024 have relatively poor corrosion resistance and can be improved considerably when coated with pure aluminum. For example, aluminum coatings on 7075 alloy parts have been found to improve stress corrosion resistance ten times.

The coatings are also useful on aluminum die castings. Such castings cannot be anodized because of their silicon content. However, die castings coated with pure aluminum are readily anodized. This is important in decorative applications and where good abrasion resistance is needed.

As is well known, thin vacuum metallized coatings can be readily applied to plastics and other nonmetallics by conventional methods. However, comparatively high temperatures are required when applying heavy coatings by the new process. Consequently, heavy coatings cannot be applied to plastics because of their inability to conduct heat away fast enough.

Surface preparation

As in any metallizing operation a clean surface is essential. Sandblasting is sufficient for many nondecorative parts where a polished appearance is not necessary. Oily surfaces should be degreased. All acidic materials should be avoided on parts where there is a possibility of hydrogen embrittlement. However, acidic treatments can be used on the lower alloy steels and other metals not susceptible to hydrogen embrittlement.

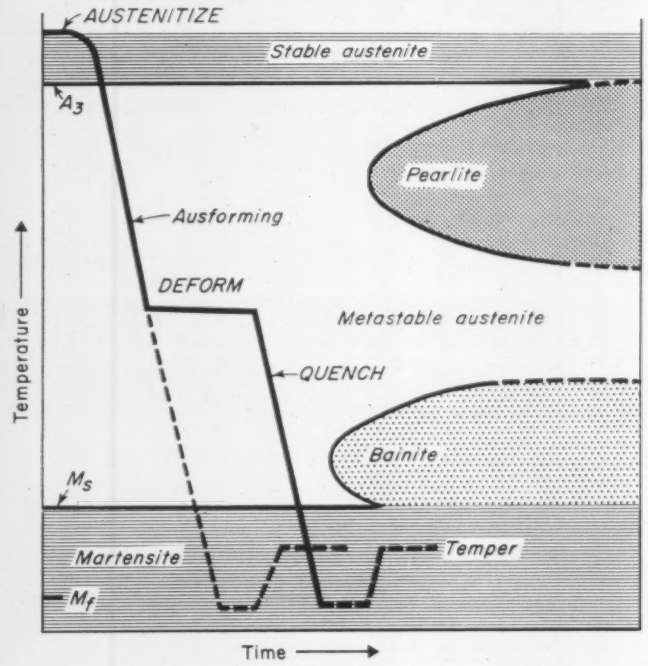
Application

Until recently the development of heavy coatings has been held back by the problem of evaporating large quantities of metal quickly and efficiently. This problem has been solved by using a crucible or boat of the coating metal and heating it by induction. This evaporation method is similar to those used for continuous and semicontinuous coating of plastics films and paper.

Aluminum coatings 1 mil thick have been applied as quickly as 5 sec in the laboratory; however, these coatings are normally applied commercially in about 5 min. Cadmium coatings can also be applied quickly, but are usually applied in a few minutes. Unlike the conventionally thin coatings which have a columnar structure, the heavy coatings are equiaxial; i.e., they grow the same in all directions.

For more information, circle No. 602

Here's Where Ausforming Stands Today



Schematic isothermal transformation *diagram compares sequence of operations in Ausforming and conventional heat treatment.*

Basic Requirements for Ausforming

In order to Ausform a steel, two conditions must be met:

1. The steel must possess an isothermal transformation diagram with a deep "bay" region between the pearlite and bainite "knees."

2. The "knees" must be sufficiently displaced in time so that no interference from isothermal transformation products is encountered during the Ausforming operation.

The accompanying sketch shows the hypothetical transformation diagram of such a steel. The Ausforming process is indicated by the heavy line. A conventional quench and temper sequence is also shown.

The steel is held at a temperature in the stable austenite range above temperature A_3 for a suitable period of time in order to insure solid solution of all constituents. In conventional heat treating, the steel would then be simply quenched and tempered. To Ausform, however, the steel is transferred from the the austenitizing furnace to a second furnace or salt bath which is maintained at some temperature in the metastable austenite "bay" region. After a few minutes at this temperature to reach thermal equilibrium, the material is severely deformed in one or more steps. Subsequent quenching in either oil or air (depending on the steel composition) is followed by a tempering operation.

Observation of the microstructure of an Ausformed steel shows that the characteristic martensitic grain or platelet size has been considerably reduced. The accompanying photomicrographs, for example, show a medium alloy nickel steel after a 55% reduction in thickness accomplished by rolling at 1000 F.

Deforming steel during heat treatment increases strength as much as 35%. Further gains—as high as 50%—are predicted.

by Damian V. Gullotti,
*Republic Aircraft Corp.**

■ Steel is still the most widely used constructional alloy despite the many uses now being found for the more exotic metals under investigation. Unfortunately, the technical development of modern steel has not kept up with the high strength-to-weight requirements of astronautic construction.

Improvements in the strength of steel during the past five years have been obtained by lowering tempering temperatures, modifying and improving alloy compositions, and improving steelmaking techniques. The first approach results in decreased ductility and toughness; the latter two result in only moderate strength increases.

Ausforming combines increased strength with good ductility. The method consists of quenching a steel to some intermediate temperature at which austenite is metastable, working the austenite, and then quenching to a martensitic structure.

How is steel strengthened?

Basically, all strengthening processes in metals involve the introduction of strain into the metal lattice. This can be accomplished in a number of ways: work hardening, alloying, precipitation hardening, etc. Conventional heat treatment uses the phase transformation from the face centered cubic phase, austenite (stable at high temperature), to the body centered cubic phase, martensite (stable at lower temperatures), to develop the high strength of steel.

If the cooling cycle of the steel is interrupted, and if composition of the steel is such that transformation of the austenite can be

* Now with Research Laboratory, International Nickel Co.

PROPERTIES OF SOME STEELS AFTER AUSFORMING AND CONVENTIONAL HEAT TREATMENT

Steel	Deformation			Tensile Strength, 1000 psi		Yld Str (0.2% offset), 1000 psi		Elongation, %		Source
	Percent	Temp, F	Method	Ausformed	Normal	Ausformed	Normal	Ausformed	Normal	
D6A	71	1100	Forged	450	300	325	235	6	10	Ladish
4340	71	1100	Forged	320	275	260	225	5	10	Ladish
V48[a]	90	1000	Rolled	440	346	300	220	9	5	Ford Motor
V63[a]	90	1000	Rolled	480	335	335	245	8	1	Ford Motor
Halcomb 218	50	900	Spin Formed	384	285	300	225	9	4.5	General Electric
LaBelle HT	65	900	Spin Formed	373	270	352	240	5	6	General Electric
Super Tricent	65	900	Spin Formed	343	315	300	255	10	6	General Electric

[a] Experimental steel.

supressed, then the austenite is considered to be in a metastable condition. Plastically deforming the metastable austenite before it transforms to martensite results in a final structure of highly strained martensite possessing enhanced strength.

Several names for this approach to higher strength steels have been suggested, but the term Ausforming, trademarked by Ford Motor Co., seems to have gained the widest acceptance.

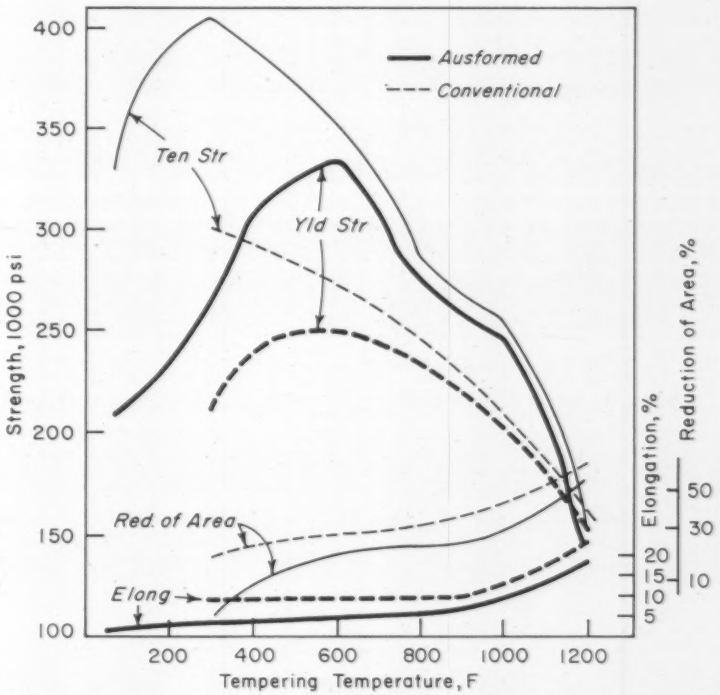
It was first demonstrated in 1954, by research workers in Holland, that this process can produce stronger steels. A 40% increase in strength with excellent ductility was claimed. This early investigation claimed to produce a steel with a yield strength of 400,000 psi while maintaining a 42% reduction of area.

What does Ausforming do?

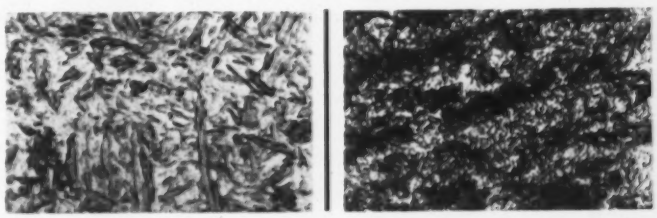
Although claims made by the Dutch workers have not been fully substantiated, recent data do indicate that gains in strength may be made without serious loss of ductility.

Both yield and tensile strengths are improved as much as 35% in a number of steels after deformations of 70 to 90%. Some unconfirmed results have indicated that better than 50% improvement may be obtained in the not-too-distant future.

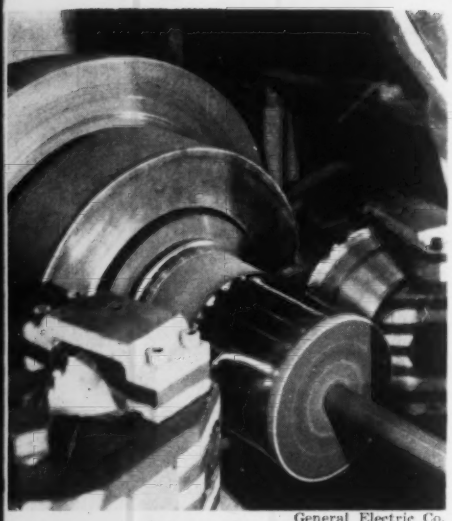
Mechanical properties of several steels compared with their best values after Ausforming are presented in the table. In all cases tensile and yield strengths show a distinct improvement over those of conventionally heat treated



1—Mechanical properties of D6A steel: how Ausforming compares with conventional heat treatment.



Photomicrographs *show how Ausforming refines martensite platelets. Conventionally treated steel is at left, Ausformed steel at right (500×).*



General Electric Co.

2—*Ausforming sub-scale cylinders by power spinning at elevated temperature. Full-size cylinders will be used for solid fuel rocket cases.*

steels. Ductility values vary: some steels show an improvement; for others ductility decreases.

Effects of tempering an Ausformed steel are shown in Fig 1. Data shown are the result of a 4-hr tempering treatment. Properties of the steel, Ladish D6A, are up to 35% higher than those of the conventionally heat treated material after tempering. In addition, the improvement in properties is retained to a relatively high tempering temperature. In this case, Ausforming resulted in lower ductility values.

The Ausforming procedure used for the D6A specimens was hammer forging 70% in the metastable austenite bay at 1100 F followed by oil quenching.

Directional properties — Although a deformation texture is not normally obtained in the hot working of steel, it was recently shown that this type of preferred orientation can result after Ausforming. Subsequent investigation indicated that the effect on mechanical properties in the longitudinal and transverse directions was not significant. Although some differences were observed, they were slight ones.

From a practical point of view, the deformations needed to achieve significant strengthening through Ausforming are extremely severe. There are many difficulties in obtaining these reductions in single deformation operations. Reductions of the degree necessary can be secured by stepwise deformation, however, with intermediate returns of the steel to the furnace or salt bath. It has been shown that multiple pass rolling, reheating and reforging have no significant effect on the final properties of the steel when compared with reductions obtained in a single deformation step.

Approaches to deformation

There is some question as to the best way in which to Ausform. Several techniques now being investigated include:

1. *Rolling.* This is the method most frequently used to date. Except for experimental purposes, the technique is impractical since only the simplest shapes can be formed. Joining these simple shapes by any fusion method will destroy the enhanced properties in the immediate area of the weld deposit and heat-affected zone.

2. *Forging.* This approach seems to hold much promise, since relatively complex sections can be formed which require little subsequent reworking.

3. *Hot spinning.* This technique has been applied successfully to Ausform motor cases for a solid fuel rocket (see Fig 2). A ring forging heated to austenitizing temperature is placed on a mandrel kept at the deformation temperature. A series of spinning passes are made using a specially designed roll until the required degree of deformation is achieved. Quenching and tempering of the finished cylinder complete the treatment.

4. *Contact explosives.* This method is still experimental, and no information is available concerning practicality.

5. *Other methods,* such as wire drawing and shot peening. These methods are of limited value and for very specific applications.

Whatever the complex relationships involved in the strength improvement resulting from Ausforming, it is still a highly experimental technique. A great deal of experimental and theoretical work is needed to clearly define and improve the understanding of the strengthening mechanisms. With increased clarification, it is thought that even greater property improvements may be realized.

(more What's New on p 224)

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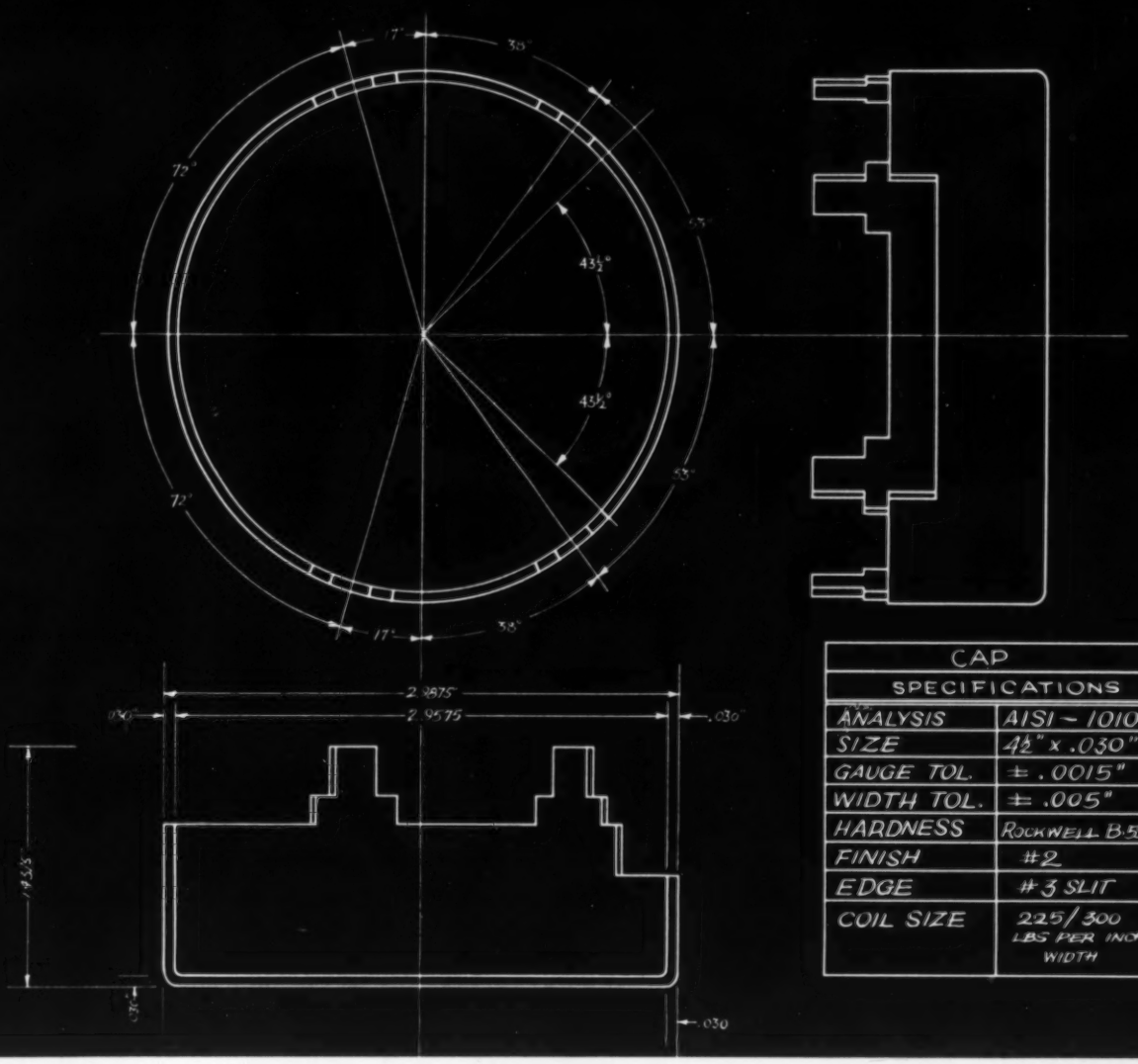

CAP SPECIFICATIONS	
ANALYSIS	AISI – 1010
SIZE	4½" x .030"
GAUGE TOL.	± .0015"
WIDTH TOL.	± .005"
HARDNESS	ROCKWELL B-55 MAX
FINISH	#2
EDGE	#3 SLIT
COIL SIZE	225/300 LBS PER INCH WIDTH

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Letters to the Editor

High energy rate forming processes

To the Editor:

We were interested in the article "High Energy Rate Forming Processes" which appeared in the July '60 issue of M/DE, p 89.

The Dynapak process seems to have the most promise for the applications we have in mind, and we would appreciate your referring us to the manufacturer of the equipment.

DAVID MARGOLIS
Manager
Fish-Schurman Corp.
New Rochelle, N. Y.

The manufacturer of Dynapak equipment is Convair Div. of General Dynamics Corp., 1243 Transit Ave., Pomona, Calif.

Right town, wrong street

To the Editor:

We note from an item appearing in the June '60 issue of your magazine, p 6, line 18, that you have listed our address as 268 Madison Ave. We haven't been at "268" in more than 2½ years and would appreciate your changing your records so as to read 750 3rd Ave., New York 17.

WILLIAM J. EAST
Supervisor of Advertising
National Starch and Chemical Corp.
New York City

Handbook on materials processing

To the Editor:

Some time ago I subscribed to your magazine and received a copy of your handbook *Parts and Forms for Design Engineering*. The handbook has been of considerable value to me in my capacity as supervisor over the production of aircraft parts.

The handbook is also used by all my employees to familiarize themselves with various types of sheet metal forming techniques.

We are also interested in various types of processing such as electroplating, vacuum deposited coatings, hard facing, heat treating high temperature steels, hard anodizing, chemical milling, etc.

Is it possible that a handbook covering this field is available, and, if so, where could it be obtained?

R. L. SCHAFFER
Foreman
Manufacturing Administration
North American Aviation, Inc.
Columbus, Ohio

Although we know of no one handbook covering all the industrial processes mentioned, we suggest our own Materials Selector, *the fourth edition of which*

FOR FREEDOM OF DESIGN SPECIFY

B&W *Job-Matched seamless pressure tubing*

B&W's complete range of sizes and grades, and ability to produce long length tubes . . .

- permit the choice of the tube best for your job
- reduce field fabrication problems
- simplify procurement of tubing materials

Availability is only one of the many reasons why it pays to specify B&W Job-Matched Carbon or Alloy Steel Seamless Pressure Tubing. And remember matching tubes to jobs assures you long service life, and optimum low cost in addition to freedom of design. For more information call your regional local B&W District Sales Office or write for Bulletin TB-417. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pa.

SEE OUR EXHIBIT
Steel Arena
1960 METAL SHOW
PHILADELPHIA
OCT. 17-21
BUILD IT BETTER WITH AMERICA'S STEEL

Steel

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Seamless and welded tubular products, solid extrusions, seamless welding fittings and forged steel flanges—in carbon, alloy and stainless steels and special metals

For more information, turn to Reader Service card, circle No. 335

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SELF LUBRICATING
LOW FRICTION
STABLE AT HIGH TEMPERATURES

*carbon-graphite especially designed for mechanical applications

Sliding or rotating components compounded and molded of Purebon are self-lubricating; the material is unusually stable at high temperatures. It is readily machinable, chemically inert, light weight, low cost when moldable to size. Send prints or parts for prompt quotation.

PURE CARBON CO., INC.
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For more information, turn to Reader Service card, circle No. 442

will be issued this fall; Engineering Materials Handbook *(McGraw-Hill Book Co.); and* Handbook of Engineering Materials *(John Wiley & Sons, Inc.).*

A place for magnesium

To the Editor:

On page 144 of M/DE's June '60 issue there is a chart showing temperature-time requirements of future air vehicles compared with maximum use temperature ranges of various materials groups. The chart is credited to Battelle Memorial Institute.

I was somewhat chagrined by the chart, for while it shows aluminum well down in its temperature application, there is above the aluminum area a wide open space before we come to titanium and progressively to steel, nickel, molybdenum and tungsten. The wide open space is right now one of magnesium's major markets and most useful area of application.

I am not being critical; I am merely trying to learn why the world's lightest structural metal gets overlooked so often.

J. SINGLETON
Executive Secretary
Magnesium Assn.
New York, N. Y.

Microporous plastics for milk

To the Editor:

With reference to M. B. Richardson's letter about a porous material for milk (M/DE, June '60, p 16), I suggest he try microporous polypropylene as produced by ESB-Reeves Co., Yardley, Pa.

C. H. THOMAS
Enjay Co., Inc.
Elizabeth, N. J.

Author disowns article

To the Editor:

I have received a tear sheet of an article entitled "Which Brazing Alloys for Vacuum Systems?" (M/DE, July '60, p 116) which was very poorly rewritten from a manuscript I supplied.

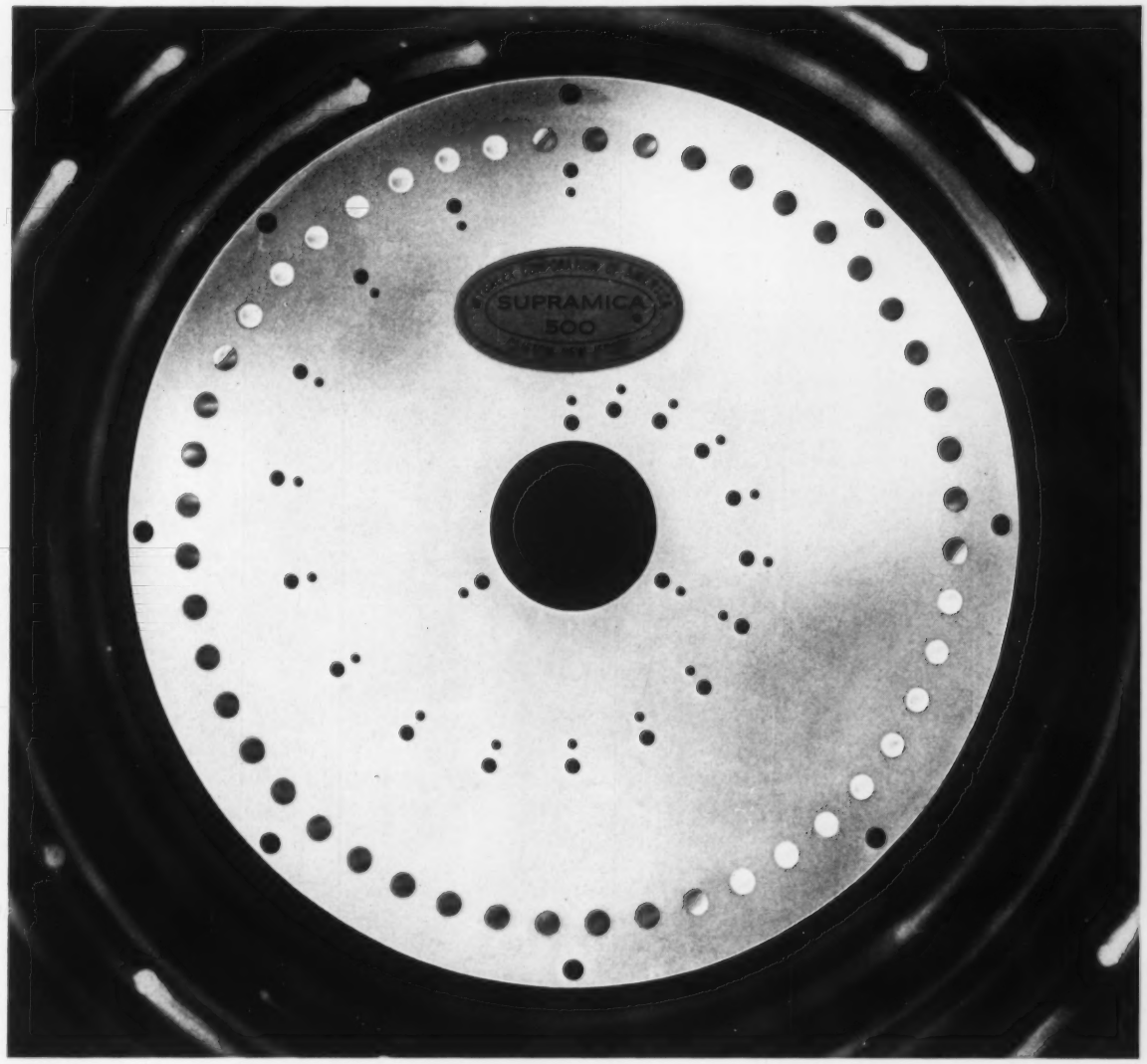
Since I was not given the opportunity to edit or approve your rewriter's garbled version of my manuscript, I do not feel obligated to take the dubious credit for it.

I ask, therefore, that you make it clear to your readers that this article was excerpted by your editorial staff and not proofread by the author.

WALTER HACK
President
Western Gold & Platinum Co.
Belmont, Calif.

Mr. Hack's article was extensively revised in the interests of clarity and brevity but, through an oversight, was not checked with him prior to publication as is our policy.

When the requirements seem impossible...



48 precious metal contacts on a 12" circle... maintaining .0003 T.I.R. planar tolerance

To SEE under the sea takes a scanning commutator with seemingly impossible tolerances to insure reliability in ship sonar. That is why compression-molded SUPRAMICA® 500 ceramoplastic machinable insulation was chosen . . . a proud example of MYCALEX CORPORATION OF AMERICA craftsmanship.

The specifications are most demanding, the requirements highly critical . . . plates must be flat within .0003" and embody precision-machined recesses to accept 48 pure silver contacts. The angular displacement of the contacts is held to ±1 minute. The combination of contacts and SUPRAMICA 500 together must accept a 2 micro inch surface finish. The application requires that these tolerances are guaranteed for the life of the commutator during which the environmental conditions run the gamut of humidity and temperature.

The MYCALEX fabricating facility is not only fully qualified to furnish the fabrication of such parts but will design and provide required hardware. For gauge-like specifications on large production runs or short prototype quantities . . . our engineers are ready, capable, and equipped to assist you with your design and production requirements. Write for information on SUPRAMICA ceramoplastics offering maximum temperature endurance (unstressed) up to +1550°F. and SYNTHAMICA® synthetic mica with maximum temperature endurance (unstressed) up to +2000°F. . . . the family of the world's most nearly perfect insulation materials.

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Clifton, N. J.

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CORPORATION OF AMERICA

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New York 20, N. Y.

World's largest manufacturer of ceramoplastics, glass-bonded mica and synthetic mica products

For more information, turn to Reader Service card, circle No. 420

To trap microparticles ... or vibration ... rely on A+ Felts

The versatility of A+ Felts makes them ideal for solving engineering and design problems as different as purifying liquids or gases with the AFCO FEUTRON® felt filter cartridge, and isolating machinery vibrations with VIBRA-MOUNT® absorber pads. These are but two of the end-results of the custom engineering with which A+ Felts are created to meet demanding sets of specifications.

The AFCO FEUTRON felt filter cartridge is precision engineered of chemically pure fibers . . . of uniform diameter . . . giving consistent cartridge density and filter performance throughout its micron range. VIBRA-MOUNT felt is used for insulating production equipment, business machines and sensitive instruments. It reduces transmitted vibration by as much as 85%.

Learn how A+ Felts can improve *your* application. Send us your materials problem. Our engineers will follow through promptly.

A+ FELT ABSORBS, SEALS, INSULATES, FILTERS, CUSHIONS, POLISHES, DECORATES

Send for this helpful **FREE** brochure showing the many uses of A+ Felt as a design and engineering material.

American Felt Company

For more information, turn to Reader Service card, circle No. 326

PRICES & SUPPLY

...AT A GLANCE

A 66% price cut on fibrous potassium titanate has been announced by Du Pont. Price for loose fibers is now $5.10 per lb, down $11.40 per lb. Lumps and cut lumps sell for $4.25 and $4.50 per lb respectively. The thermal insulating material, called Tipersul, was introduced last year (M/DE, Jan '59, p 117).

A new process for producing columbium metal was announced recently by Battelle Memorial Institute. It is a fluidized bed vapor deposition process in which hydrogen is used to reduce columbium pentachloride. Columbium produced by the method is said to be at least as good as premium-grade columbium metal now on the market.

A significant increase in the size of finished molybdenum forgings for use in missiles, aircraft and other applications is now possible because of the availability of larger forging billets. Refractomet Div. of Universal-Cyclops Steel Corp. recently produced what it claims is the "world's largest" arc-cast molybdenum ingot; it measures 17 in. in dia by 69 in. long and weighs 5000 lb.

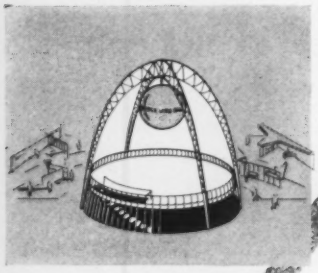
Increased production of molded graphite is foreseen with the development of a new synthetic binder (composition not disclosed) that cuts graphite's production time from its present 90 days to less than 2 hr. The binder, developed by Armour Research Foundation, is expected to reduce the price of graphite.

Price reductions on chlorinated polyether pipe have been announced by Tube Turns Plastics, Inc. and Polymer Corp. of Pa. Polymer Corp.'s pipe has been reduced 30%, Tube Turns 25%. The price reductions were made possible by a recent reduction in cost of raw material (M/DE, July '60, p 19).

Price of tin is less likely to fluctuate as the result of a new marketing plan recently approved by the United Nations Tin Conference. The plan works as follows: when tin prices approach the upper limit of $1.10 per lb, the manager of a buffer stock sells some of his tin reserves to increase the supply available on the open market and bring down or stabilize the price. Conversely, when there is too much tin for sale and the price slips toward an agreed low of 91¼¢ per lb, the manager buys some of the surplus to shorten the supply and end the price slide.

Production of polyether, a major ingredient used in urethane foams, is slated for a 20 million-lb-per-year increase when Allied Chemical Co.'s new plant goes into full production next summer. The material, used in both rigid and flexible foams, will be marketed by the company's National Aniline Div.

Primary magnesium ingot production for the first six months of this year is running 67% above the like '59 period, according to the Magnesium Assn. Production to date is 16,675 tons compared to 10,003 tons produced during the same period last year.



Theme Tower Symbol of the 1960 Metal Show

Why we plan to be in Philadelphia October 17

"ASM brings together in one place and at one time the year's most important developments in the technical and practical aspects of the metals industry. Never have I left a show without several ideas for applications of materials, equipment or processes in my engineering work. The 1960 Metal Show promises me more 'take home' than ever."

Raymond J. Hibbeln,
Dept. Chief, Product & Development Engineering
WESTERN ELECTRIC COMPANY

"The problem of keeping abreast of new developments in today's rapidly changing technology is always difficult. The Metal Show, through its audio-visual presentations of current advances in knowledge, presents a time-condensed package for those interested in metals engineering and processing."

R. F. Thomson, Head
Metallurgical Engineering Dept.
Research Laboratories
GENERAL MOTORS CORP.

Design engineering experts know the value of the 1960 Philadelphia Metal Show—how stimulating it will be—and that's why they plan to attend. They know that new emphasis on the essential metals and materials, processes and techniques will make the 1960 Show more valuable than ever before . . . providing some 300 exhibits and 250 technical papers. Attendance is a sound investment for you and your company!

"Our materials engineering responsibility extends from A (Aluminum) to Z (Zirconium). We plan to take to Philadelphia in October a series of questions concerning specific problems that need resolution at that time. The people that have the answers to these problems will be there as vendors, authors, or co-workers."

G. F. Kappelt
Chief Metallurgist
BELL AIRCRAFT CORP.

NATIONAL METAL CONGRESS and EXPOSITION

Philadelphia Trade & Convention Center • October 17-21

Sponsored by the AMERICAN SOCIETY FOR METALS *Metals Park • Novelty, Ohio*

Cooperating Activities: The Metallurgical Society of AIME; Society for Non-destructive Testing, Inc. Associations presenting technical sessions in cooperation with ASM: Metal Powder Industries Federation; Metal Treating Institute; Ultrasonic Manufacturers' Association; Industrial Heating Equipment Association; Special Libraries Association—Metals Division; American Society for Testing Materials—Committee B-9; and extensive research and engineering programs of the American Society for Metals, and ASM Seminars.

For more information, turn to Reader Service card, circle No. 330

Engineers Want More Recognition, Higher Pay, Better Use of Talents

About 25% of the engineers in industry believe that engineers are thought of as second class professionals; no industrial managers agree with this opinion . . .

More than 60% of the engineers in industry think there is considerable mal-utilization of engineers; 30% of industrial managers agree . . .

Over 50% of the engineers in industry feel that higher pay would advance the engineering profession; only 20% of industrial managers agree . . .

Based on 250 interviews

These were some of the findings reported in a survey entitled "Engineering Professionalism in Industry" conducted by the Professional Engineers Conference Board for Industry in cooperation with the National Society of Professional Engineers. A summary of preliminary findings, based on extensive interviews with 209 engineers and 40 managers, was presented at the recent annual meeting of the NSPE.

The primary objective of the study was to find out what engineers and engineering managers mean by professionalism and how they think it can be best advanced.

Engineers, managers differ

Other interesting statistics resulting from the interviews:

1. Fully 90% of the managers questioned stated that they regarded engineers as among the employees making the most contribution to the company; less than 50% of the engineers felt that they were so regarded by management.

2. Almost 50% of the managers claimed that management tries to produce a creative atmosphere; only 25% of the engineers stated that this was so.

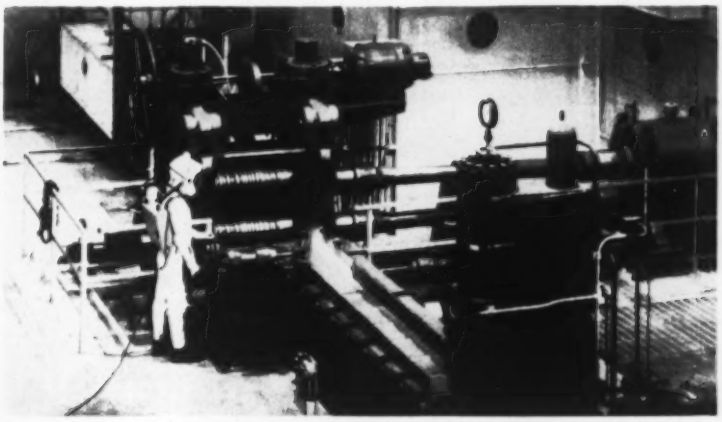
3. Whereas 68% of the managers indicated they believed management shows genuine respect for engineers, only 36% of the engineers agreed.

Company policy has effect

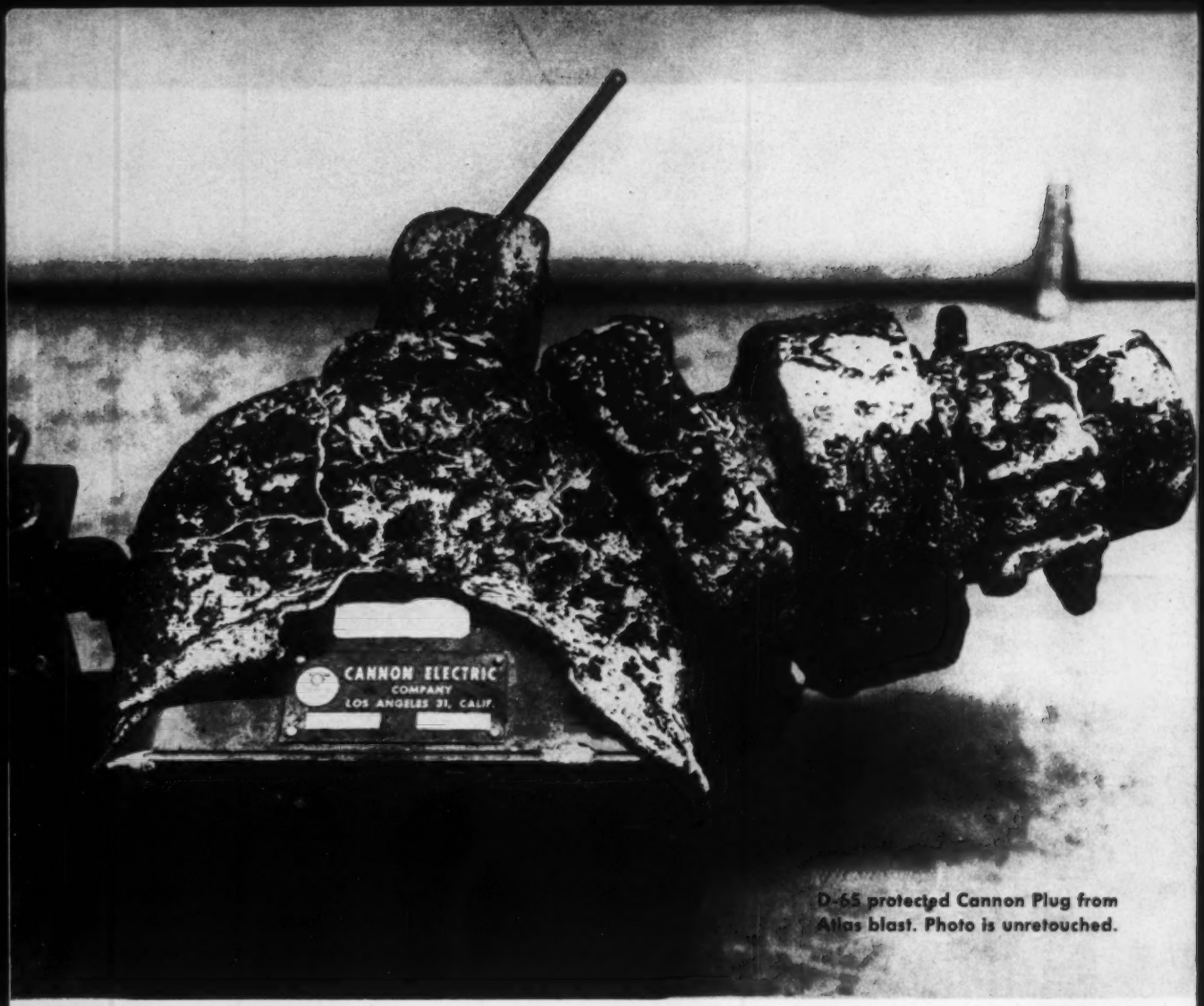
The survey also found considerable difference in professional attitudes between engineers in companies which would score high on efforts to encourage and develop high standards of engineering professionalism and engineers in those companies which would not score so high in such an evaluation.

For example, 44% of the engineers in the "high scoring" companies said that management really believes in the professional status of engineers, while only 7% of the engineers in the second type of company felt this way.

Also, 53% of the engineers in



Refractory metals of high integrity are now being fabricated in the unique argon-filled room shown in the photo above. The argon-filled room, called InFab (Inert-Fabrication), is a welded steel enclosure 42 ft wide, 97 ft long and 23 ft high containing an impactor, a rolling mill, furnaces and a 10-ton crane. Built by the Refractomet Div., Universal-Cyclops Steel Corp., InFab will be used to produce mill products of molydbenum, columbium, tantalum, tungsten, and their alloys. Primary advantage of the facility: ability to forge and roll refractory metals at temperatures up to 4500 F, thus providing truly hot worked materials which do not suffer from oxidation and contamination by other elements in the air.



D-65 protected Cannon Plug from Atlas blast. Photo is unretouched.

NEW D-65

flame resistant flexible coating protects ground support and missile equipment from rocket blast

Proved in Atlas test firings: protection at up to 5400° F for 62 seconds—ease of application at the scene by ordinary paint brush, spray or dip methods—ease of removal and recoating—flexibility after curing. These are some of the advantages of new Dyna-Therm D-65 insulation that promise reduced ground equipment refurbishment time and faster missile refire. Case in point: this standard GMAB electrical connector manufactured by Cannon Electric Company. Coated with D-65 and exposed to Atlas blast, it was found undamaged when coating was cut away as shown. Similar test of coated umbilical cord at 5400° F for 62 seconds found cord undamaged, D-65 coating still flexible.

D-65 has been successful in insulating neoprene cables, metal and plastic instrumentation housing, piping and general structure, in flight applications and ground support equipment.

Dyna-Therm D-65 was developed by Dyna-Therm Chemical Corporation and is marketed exclusively in the U.S. and Canada by Swedlow Inc. Prime contractor for the Atlas is Convair-Astronautics, a Division of General Dynamics Corporation.

Write for data, Dept. 18.

Swedlow

SWEDLOW Inc. LOS ANGELES 22, CALIFORNIA • YOUNGSTOWN 9, OHIO

For more information, turn to Reader Service card, circle No. 467

the second type of company said that engineers are "sort of a commodity—let go quickly if business is poor." Only 17% of the engineers in the "high scoring" companies held this view.

Finally, 82% of the engineers in the second type of company said there was considerable mal-utilization of engineers, while only 44% of the engineers in the "high scoring" companies felt this was true.

The survey concluded that many of the problems in engineering professionalism "seems to be due to a lack of two-way communication between engineers and managers."

Metal Show in October

The 42nd Annual Metal Congress and 1960 Metal Show will be held Oct 17-21 in Philadelphia's Trade and Convention Center.

This year's Congress, sponsored by the American Society for Metals in cooperation with eight other technical societies, will consist of about 250 technical papers, panels and symposia on the most significant developments in metal science and engineering during the past year.

The Metal Show, sponsored by ASM, will concentrate on specific engineering data on metals and related engineering materials, the form in which they are used, and the manufacturing and fabrication processes best suited to a particular product.

For details on technical program, exhibitors and registration, see the October issue of M/DE.

World's Most Powerful Magnet to Study Matter, Energy

A comprehensive search for new knowledge about the nature of matter and energy will be undertaken in a new laboratory that will house what is said to be the world's most powerful magnet.

Air Force aids MIT

The laboratory, to be completed in 1964, is being built at Massachusetts Institute of Technology under a $9,502,000 contract with the Air Force's Air Research and Development Command.

Created as a national research center, the MIT Magnet Laboratory will produce extremely high (250,000 gauss) and continuous magnetic fields for use in scientific attempts to understand and explain the behavior of matter and energy in the universe.

Practical studies, too

The high magnetic fields will be a tool with which to determine the properties and behavior of atoms, atomic particles, and aggregations of atoms in solid materials, liquids and gases. Although directed toward basic research, the new laboratory will also work in areas that have already produced many practical advances, particularly the fields of solid state and low temperature physics.

In addition, the laboratory will provide opportunities for extended work in plasma and nuclear physics where the presence of stronger magnetic fields are of critical importance.

According to Benjamin Lax, director of the new laboratory, "The laboratory will foster activities that will enrich our knowledge not only of solids but also of liquids, gases, and ionized gases, and undoubtedly will contribute to our eventual peaceful use of thermonuclear energy and to the development of new electronic devices."

FDA Approves Teflon for Food Handling

Use of Du Pont's Teflon TFE fluorocarbon resins in food handling service has been approved by the Food and Drug Administration.

According to Du Pont, the ruling paves the way for dozens of new applications, many of which are already well along in their development stages. An important area into which use of the resins is expected to expand is food processing. Typical uses include:

1. Conveyor belts in candy manufacturing processes.
2. Non-stick coatings and films used in both baking and candy-making processes.
3. Gaskets, seals, packings, non-lubricated bearings, and other molded parts of food processing machinery.

Du Pont says that one TFE resin, Teflon 6, has already been accepted by FDA (Aug '59) for use in milk-handling equipment. The latest action, however, gives virtual across-the-board clearance to all products fabricated from virgin TFE resins.

News of Societies

Alloy Casting Institute has elected as president J. D. Hagans, Ohio Steel Foundry Co. Re-elected were: vice-president—J. S. Wooters, General Alloys Co.; and executive vice president and treasurer—E. A. Schoefer.

International Powder Metallurgy Conference presented a plaque to Dr. Paul Schwarzkopf in commemoration of his 50 years of work in the field of powder metallurgy.

Coming Meetings on p 31 ⟶

Extruded and machined parts . . .
8 different AlSiMag compositions

Pressed AlSiMag ceramics . . .
9 different compositions

Machined natural stone

AlSiMag®

offers . . .

the widest variety of technical ceramics from any single source

Specialized engineering talent in depth • The quantity you need . . . deliveries and quality as agreed • Special speedy service on prototypes • Specialized equipment for smaller quantity production • Unequaled facilities for volume production when you really need volume.

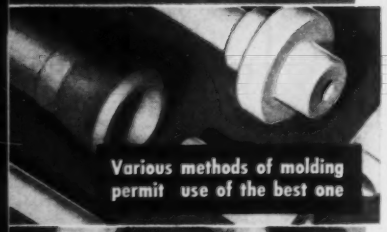
from one source . . .

These are typical samples picked up in our Inspection Department over a week end. They illustrate the great variety of technical ceramics constantly flowing through our ultra-modern plants.

Parts are shown approximately ½ size.

Property Chart Sent on Request.

Odd contours can be handled in specialized molding processes

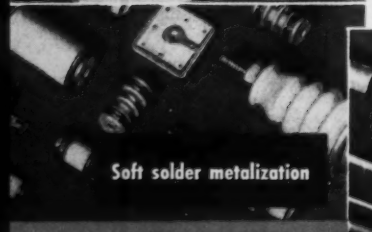


Various methods of molding permit use of the best one

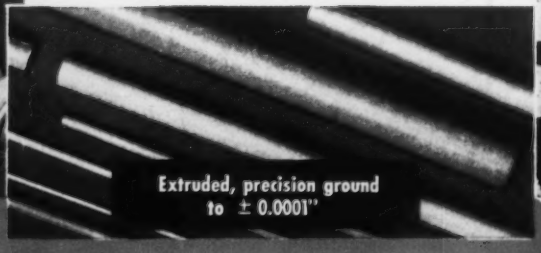
AlSiMag metal-ceramic assemblies

Casting handles larger shapes, odd contours

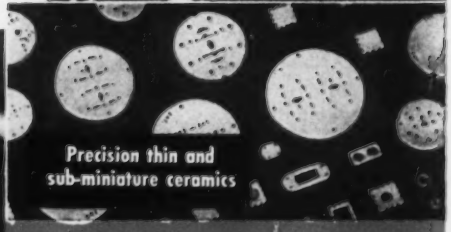
High temperature hermetic seals



Soft solder metalization



Extruded, precision ground to ± 0.0001"



Precision thin and sub-miniature ceramics

For more information, circle No. 327

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All other export: Minnesota Mining & Manufacturing Co., International Division, 99 Park Ave., New York, N. Y.

News OF INDUSTRY

Coming Meetings

MACHINE TOOL EXPOSITION, National Machine Tool Builders' Assn. Chicago. Sept 6-16.

AUTOMATIC CONTROL CONFERENCE, American Society of Mechanical Engineers, American Institute of Chemical Engineers, Instrument Society of America and Institute of Radio Engineers. Boston. Sept 7-9.

AMERICAN CHEMICAL SOCIETY, 138th national meeting. New York City. Sept 11-16.

AMERICAN DIE CASTING INSTITUTE, annual meeting. Chicago. Sept 14-15.

ENGINEERING MANAGEMENT CONFERENCE, American Society of Mechanical Engineers and American Institute of Electrical Engineers. Chicago. Sept 15-16.

METAL POWDER INDUSTRIES FEDERATION, fall meeting. Bretton Woods, N. H. Sept 15-18.

STEEL FOUNDERS' SOCIETY OF AMERICA, 58th fall meeting. Hot Springs, Va. Sept 18-20.

POWER CONFERENCE, American Society of Mechanical Engineers and American Institute of Electrical Engineers. Philadelphia. Sept 21-23.

NATIONAL FOUNDRY ASSN., annual meeting. Chicago. Sept 22-23.

AMERICAN WELDING SOCIETY, INC., national fall meeting. Pittsburgh. Sept 26-29.

RUBBER AND PLASTICS CONFERENCE, American Society of Mechanical Engineers. Erie, Pa. Oct 9-12.

ELECTROCHEMICAL SOCIETY, fall meeting. Houston, Tex. Oct 9-13.

PRESSED METAL INSTITUTE, annual meeting. Shawnee-on-the-Delaware, Pa. Oct 10-14.

GRAY IRON FOUNDERS' SOCIETY, INC., 32nd annual meeting. Cincinnati. Oct 12-14.

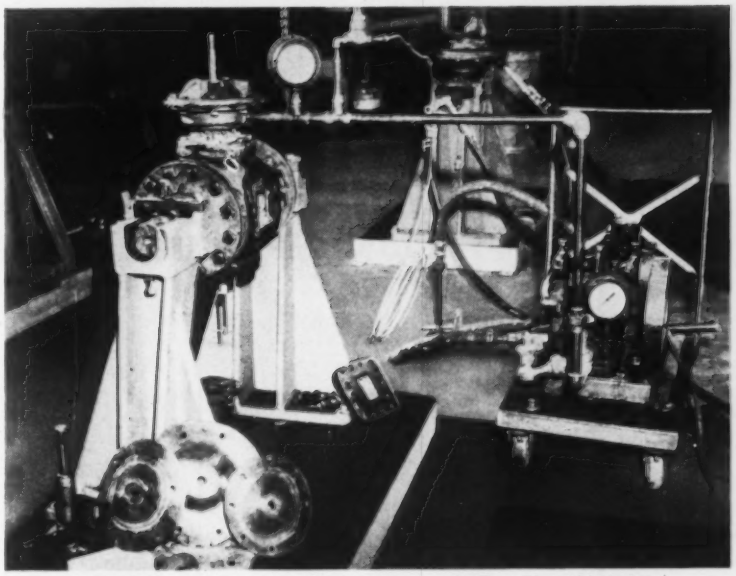
SOCIETY OF THE PLASTICS INDUSTRY, INC., 16th annual New England Section conference. Wentworth-by-the-Sea, Portsmouth, N. H. Oct 13-14.

NON-FERROUS FOUNDERS' SOCIETY, annual meeting. Asheville, N. C. Oct 13-15.

MAGNESIUM ASSN., annual convention. Cleveland. Oct 17-18.

42ND NATIONAL METAL EXPOSITION AND CONGRESS, American Society for Metals. Philadelphia. Oct 17-21.

DIAPHRAGM OF REEVECOTE WITHSTANDS 23,520 LB. THRUST IN SAFETY TEST



Safety tests for gas regulator diaphragms are run by Reynolds on this device fed by a hydraulic pump. Here, on an effective area of 24 sq. in., a Reevecote synthetic diaphragm safely absorbed a total thrust of 23,520 lbs.

The Reynolds Gas Regulator Co., of Anderson, Ind., takes unusual safety precautions to check the tensile strength of diaphragms in their gas regulators.

Some of their diaphragms must absorb sudden surges in pressure—up to 1000 psi. That's why Reynolds runs special safety tests on the diaphragms.

The results of these tests prove the outstanding superiority of diaphragms made of Reevecote.

In a recent test at Reynolds, Reevecote 7270, 0.093" gauge a Buna-N coated nylon, successfully withstood 980 psi on an effective diameter of 24 sq. in.—or a total thrust of 23,520 pounds.

Reevecote diaphragms are flexible and sensitive, yet tough enough to stand up safely under severe extremes of pressure.

If your design calls for the use of diaphragms, or coated fabrics—choose from the most complete source of coated fabrics for industry—REEVECOTE.

REEVES VULCAN

Reeves Brothers, Inc., Vulcan Rubber Products Division
1071 Avenue of the Americas · New York 18, New York

For more information, turn to Reader Service card, circle No. 445

WE PROVIDE A HAPPY ENDING TO YOUR TUBING PROBLEMS

Top refrigeration people depend on top tubing people!

Comprehensive GM Steel Tubing facilities quickly deliver your tubing processed to slip into your production line like an eel through oil. Typical are facilities for end-processing tubing to your requirements. We can hold O.D. or I.D. tolerances to a plus or minus .0015" by end sizing. And by swaging, your O.D. tolerances can be held as close as plus or minus .002". You can have external beading or recessing and we can rod draw to exceptionally close tolerances. Shearing, upsetting, flattening, piercing—we do all of them expertly. Just ask a GM Steel Tubing Sales Engineer. We're at your service. *Rochester Products Division of General Motors, Rochester, New York.*

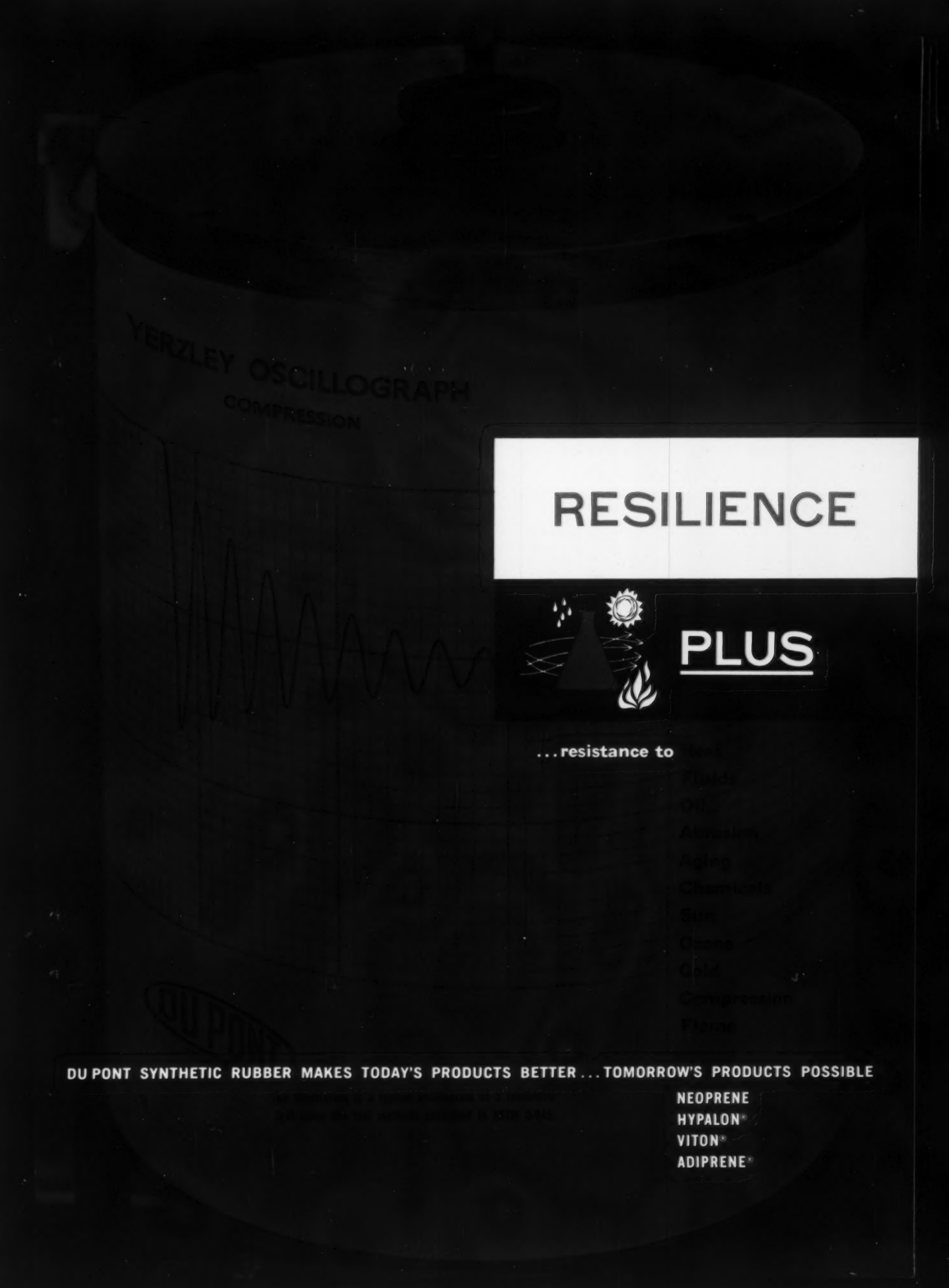
GM STEEL TUBING
BY ROCHESTER PRODUCTS

RP

AMERICA'S LARGEST MANUFACTURER OF REFRIGERATION TUBING

For more information, turn to Reader Service card, circle No. 452

For more information, circle No. 356



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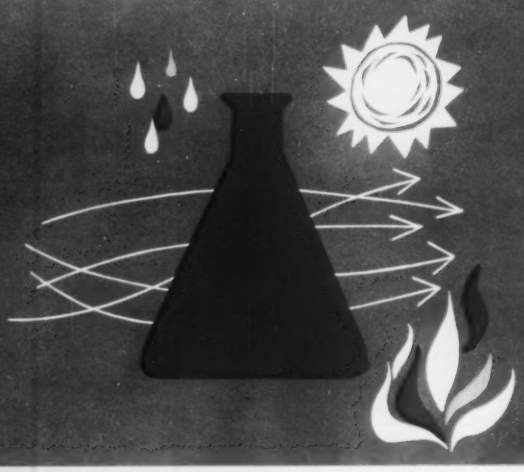
WHEN YOU NEED RESILIENCE...



NEOPRENE

RESILIENCE PLUS A BALANCED COMBINATION OF PROPERTIES

Resistant to heat, flame, chemicals, sunlight, weathering, ozone, oils, grease and abrasion... proved in performance by over 25 years of successful use in industry.

HYPALON®

RESILIENCE PLUS WEATHERABILITY AND COLORABILITY

Color stable... ozone proof... resistant to heat, oils, oxidizing chemicals, sunlight and weathering... excellent for protective paints and fabric coatings.

VITON®

RESILIENCE PLUS RESISTANCE TO HEAT AND FLUIDS

Best of all elastomers in its resistance to corrosive chemicals, fluids and solvents... performs at temperatures over 400° F.... excellent tensile strength... low compression set, high modulus... flame-resistant.

ADIPRENE® L

RESILIENCE PLUS HIGH LOAD-BEARING CAPACITY AND ABRASION RESISTANCE

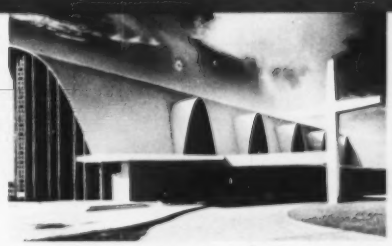
A liquid polyurethane rubber excellent for casting, potting, molding... forms a hard, resilient rubber with high load-bearing capacity, unusual abrasion resistance and outstanding low temperature properties.

Coiled heater cord for small appliances is jacketed with neoprene for long-term flexibility, resistance to heat, food chemicals and cooking oils. A test cord underwent 500,000 flexing cycles without damage.

Inflatable dam made from tube of neoprene-coated nylon is used in Los Angeles to divert river water for conservation. Test material withstood weather, sun, abrasion from river debris for two years.

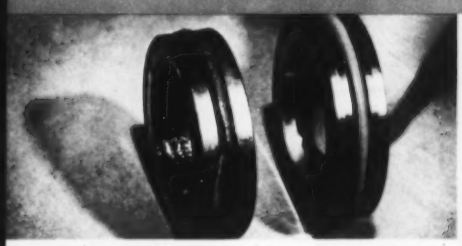
New air valve design for ventilation units is a helical spring covered with neoprene tubing. Neoprene tubing is expected to last as long as the ventilation system and still maintain a tight seal on the close-off.

House-size tarpaulin is used by fumigators to keep exterminating gases from escaping. It is made of nylon fabric coated with Du Pont Hypalon . . . resists sun, weather, fumigating gases . . . is easy to handle.

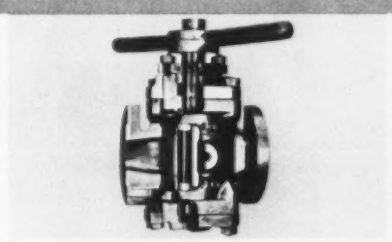


Cathedral roof with sprayed-on coating of Hypalon stays gleaming white in spite of tropical sun, wind, rain and salt spray. Weathering has not caused the reflective roof coating to dull or deteriorate since 1957.

Hypalon shows outstanding resistance to strong oxidizing chemicals. This tubing was used to pump chlorine bleach (5¼% hypochlorite) at 158° F. . . . was still good after a week. Other rubbers failed in 24 hours.

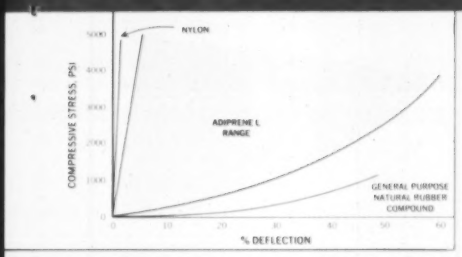


Viton O-rings seal bearings in heat exchanger at 525° F. . . . outlast other synthetic rubbers 25 to 1. They resist fatty acids, dibasic acid, phthalic acid, solvent and petroleum products . . . maintain their resilience.



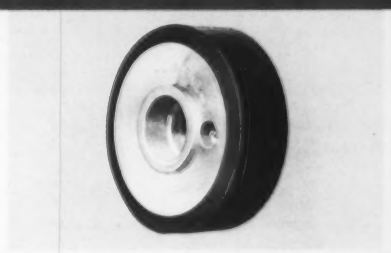
This refinery valve has been used in a benzene line for over a year. Its O-rings and valve seat —made from Viton—are still assuring positive shut-off. Viton parts also resist toluene, xylene, 380° F. alkylate gas, 400° F. propane.

Fire seals in the wings of the new B-58 "Hustler" are made from Viton-coated asbestos fabric . . . resist heat, ozone, jet fuels, fumes and corona . . . are equivalent to stainless steel in fireproofing qualities.



Load-bearing capacity of hard Adiprene L compounds ranges between that of general purpose rubber and the harder plastics. You might use Adiprene L compounds to replace non-elastomeric materials where cushioning or damping properties are needed.

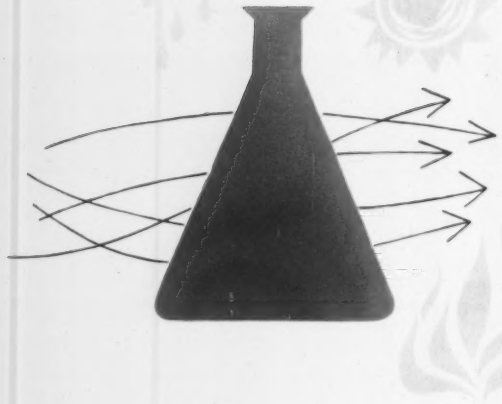
Adiprene L can be used alone or in combination with epoxy resins for potting and encapsulating electrical assemblies. Its flexibility helps protect delicate instruments from damage. It has excellent resistance to thermal shock.



Industrial wheels made of Adiprene L outlast rubber and plastic . . . are outstanding in abrasion resistance. They resist oils, mild acids and alkalies, temperature extremes, weathering and aging . . . are resilient and non-marring.

DU PONT SYNTHETIC RUBBER MAKES TODAY'S PRODUCTS BETTER . . .

TOMORROW'S PRODUCTS POSSIBLE



DO YOU HAVE THESE DU PONT DESIGN AIDS?

ENGINEERING GUIDE TO THE DU PONT ELASTOMERS—Gives you specific properties and applications of Du Pont elastomers plus comparative data on various other synthetic rubbers, chemical resistance tables, etc.

INDUSTRIAL REPORT ON VITON®—A technical report on the fluid and temperature resistance of Du Pont's new fluoroelastomer. Contains data on the performance of Viton in contact with 160 commercial fluids.

DEVELOPMENT NOTES ON ADIPRENE® L—Discusses advantages and limitations of compounds made from Du Pont's new liquid urethane elastomer. Includes data on physical, chemical and electrical properties.

THE ELASTOMERS NOTEBOOK—A periodical published bi-monthly to bring you information on the successful application of Du Pont synthetic rubbers in all phases of industry. Subscriptions free on request.

DU PONT TECHNICAL SERVICE—Du Pont synthetic rubber specialists, with experience involving all major industries, will gladly work with your supplier to develop elastomer products to fit your needs.

For further information on Du Pont synthetic rubber or for any of the above Design Aids, contact:

E. I. du Pont de Nemours & Co. (Inc.)
Elastomer Chemicals Department 391
Wilmington 98, Delaware

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AKRON 8, Ohio . . 40 E. Buchtel Ave. at High St.
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BOSTON 10, Mass. . . . . 140 Federal Street
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PALO ALTO, Calif. . . . . 701 Welch Road
TRENTON 8, N. J. . . . 1750 N. Olden Avenue

Du Pont of Canada, Limited
MONTREAL . . . . . P. O. Box 660
TORONTO . . . . . 85 Eglinton Ave., East

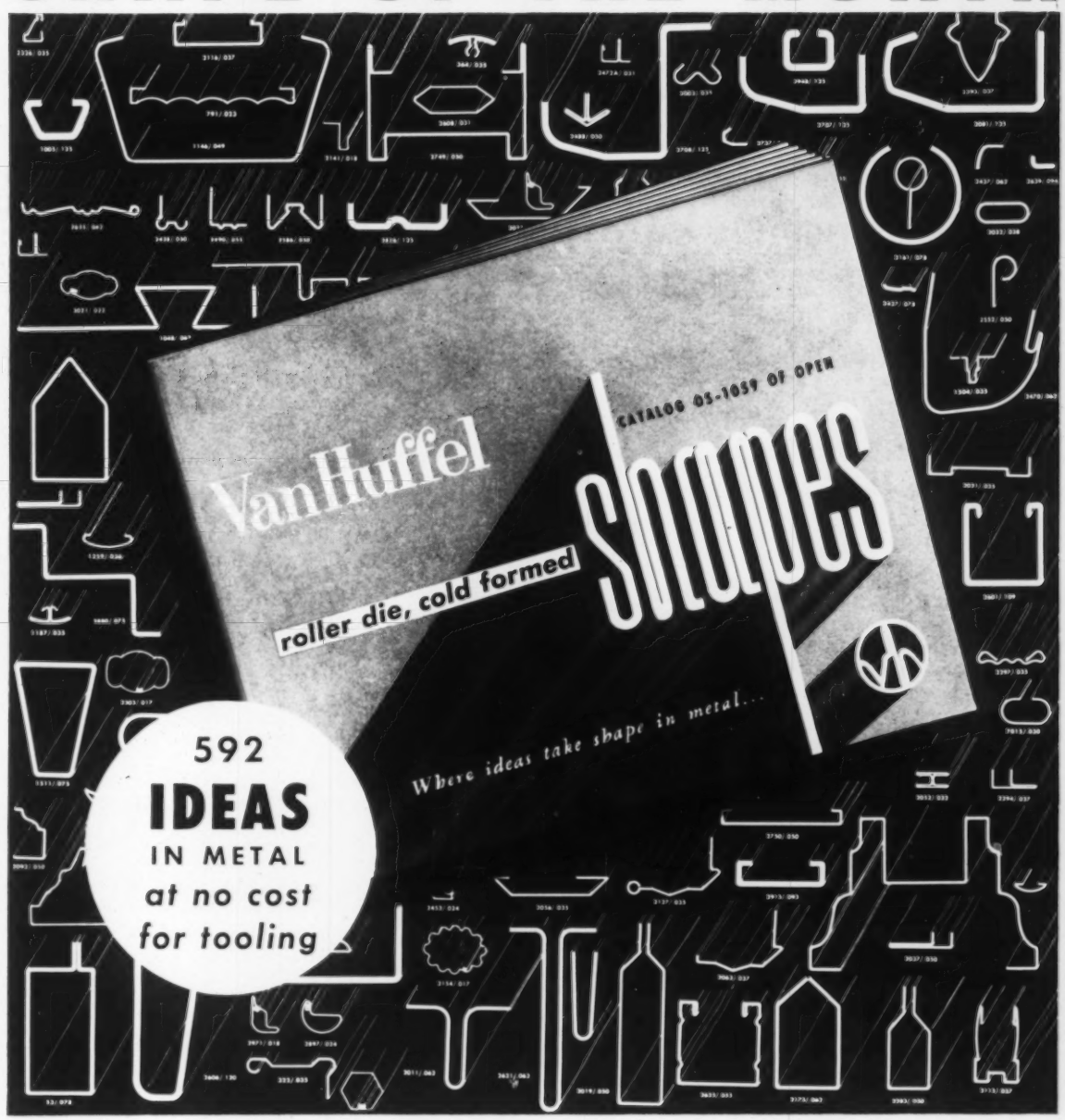
Send overseas inquiries to:

E. I. du Pont de Nemours & Co. (Inc.)
Elastomer Chemicals Department, Export Div.
Wilmington 98, Delaware

DU PONT **SYNTHETIC RUBBER**
NEOPRENE HYPALON® VITON® ADIPRENE®

Better Things for Better Living . . . *through Chemistry*

BOOK SHAPE OF THE MONTH



Illustrated, greatly reduced, are a few ideas that have taken shape in metal.

MAIL THE COUPON FOR FREE OPEN SHAPE CATALOG

48 page catalog OS-1059 illustrates (actual size) over 500 roller die, cold formed metal shapes for which rolls and dies are on hand thus eliminating tooling costs to the purchaser of any of the shapes illustrated.

Van Huffel Tube Corporation, Warren, Ohio

Please rush me Open Shape Catalog No. OS-1059.

Name ..... Title .....

Company .....

Street Address .....

City ..... Zone .. State .....

VAN HUFFEL TUBE CORPORATION — WARREN, OHIO

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the LEAD newsletter

Vol. 2 No. 3

Exciting Developments in Finishing

Ceramists have known for centuries that the most beautiful, colorful and lustrous glazes and enamels contain important quantities of lead. Modern ceramic finishes call for beauty as well as low firing temperatures. The powerful low temperature fluxing action of lead compounds perfectly suits them for the new low-temperature porcelain enamels for aluminum, steel, magnesium, low fire glazes on brick and tile and a host of other products.

Porcelain Enamels For Steel at 1000°F.

Important news in the world of metal finishing is the development of porcelain enamels for steel with extremely low firing temperatures. Based on the low temperature glass-forming properties of lead, these enamels mature in the range of 1000°F.-1100°F.

Because these enamels mature well below the transformation temperature of steel, warping is no problem. A whole range of steel products formerly limited only to organic finishes because of warping can now have the advantages of porcelain enamel. Low temperature enamels can materially reduce costs of architectural panels too! – because fuel costs are much lower – substantially less expensive furnaces can be used – and low cost cold rolled steel can be specified.

High Luster Ceramic Products

Lead glazes leave ceramics gleaming. Versatile lead compounds help glazes flow freely over ceramic body surfaces to form a hard, long lasting, brilliant coating. Melting quickly at relatively low temperatures, lead glazes save furnace time and fuel as well. And only lead-based glazes offer a wide softening range under varying kiln temperatures ... a characteristic that keeps scrap rate low. The result: a smooth fool-proof glaze that readily covers blemishes.

Glazed Insulators With High Resistivity

Passing tough military specifications for surface resistivity (7.5 x 10^{5} megohms at 95% relative humidity) lead glazes offer excellent protection for critical insulator parts from rough environmental conditions. With lead, high resistivity is achieved both on the surface by barring the formation of an electrically conductive film of water vapor and in the coating itself (volume resistivity).

Application Labels For Glass Containers

Permanent, decorative ceramic labels for bottles and glass containers would hardly be possible without lead. Lead oxide is a preferred fluxing agent, because low temperature glass-base fluxes made with it are less soluble in water and mineral or organic acids than lead-less fluxes. In protecting the strength of the glass containers, lead oxide's effective expansion coefficient factor is far lower than that of alkali oxides. Because of this, lead oxide maintains a thermal expansion coefficient well within limits compatible with the glass of the container being processed.

Spandrelite Sparkles

Lead-bearing glass enamels endow Spandrelite curtain-wall panels with jewel-like pastels, handsome chartones –a wider, more brilliant color selection.

These rugged glass panels resist shock, withstand wide temperature fluctuations, and their lead-enameled surfaces are stainproof, non-absorbent and easily cleaned. Permanently fused into the glass, the colors won't fade with time.

Building Highlighted by Porcelain Enamelled Aluminum

In New York City, the 39-story Tishman Building has better than eight acres of curtain wall construction, with each window and spandrel separated building-high by 20-inch wide, white porcelain enameled aluminum strips. Lead's low firing temperature is essential to the production of porcelain enameled aluminum panels. In addition, it provides elasticity and chemical resistance to the enamel finish. Lead-bearing porcelain enameled aluminum panels can be sheared, sawed, punched or drilled on the job with little or no chipping.

Permanent Color in Structural Clay

Lead-glazed, clay-bonded, light aggregate vermiculite – a new and improved structural material – offers many advantages. Its high strength – meeting ASTM specifications for class A concrete block – and its wide range of permanent color combine to provide the construction industry with a fine new structural clay product. It is a material excellent for both interior and exterior color styling with a smooth, self-cleaning surface. In developing the glaze, a variety of glass compositions were tested. Only lead glazes produced consistently good results in the temperature range up to 2000°F. Lead glazes provide a controlled viscosity range, allowing reaction of the glaze with the body without yielding to excessive soaking of the glaze into the porous body.

For detailed information concerning new uses, techniques and developments in lead, write to: Office of Technical Information, Lead Industries Association, 292 Madison Avenue, New York 17, N. Y.

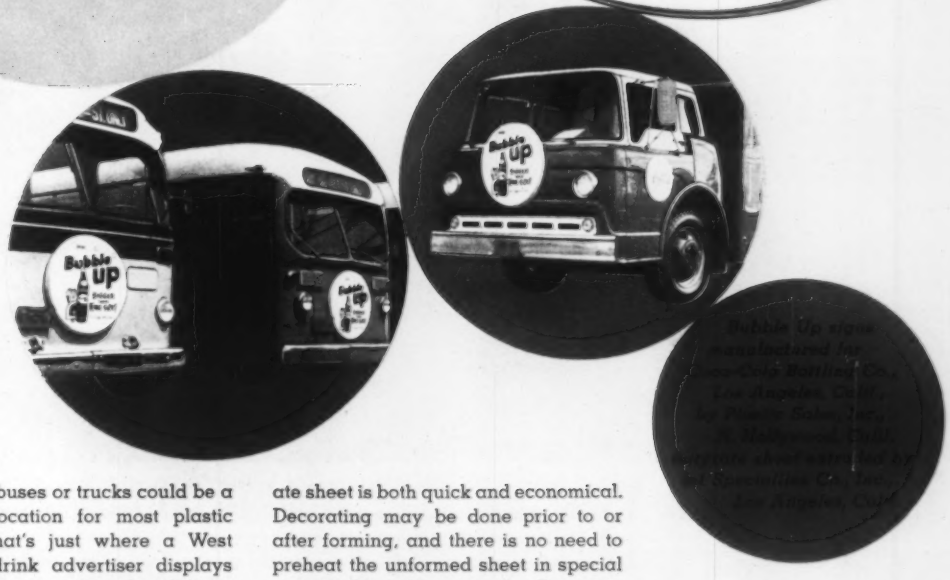
2650

LOOK AHEAD WITH LEAD

For more information, turn to Reader Service Card, circle No. 405

For more information, circle No. 363 ➤

The roughest duty is routine to signs of tough **BUTYRATE** plastic



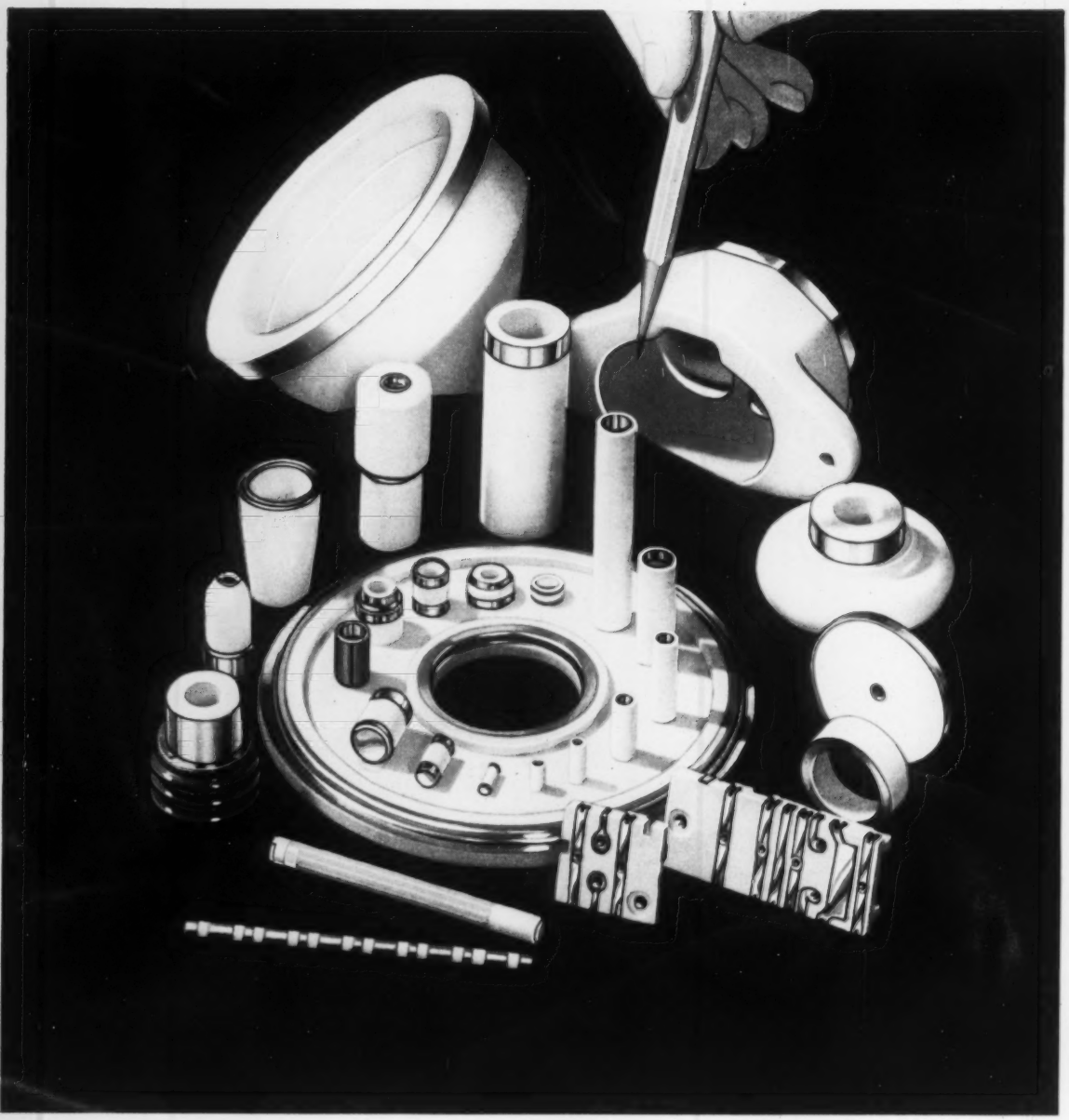
The front of buses or trucks could be a hazardous location for most plastic signs—but that's just where a West Coast soft drink advertiser displays this colorful vacuum-formed medallion. The material selected to do the job? Tenite Butyrate, of course, in special weather-resistant formulation.

Tenite Butyrate is the only weather-durable plastic sign material with the right combination of high impact strength and resilience necessary to take the hard knocks which this sign will receive. It is the same rugged material so widely used in sports equipment, appliance housings, marine accessories, and outdoor pipe.

But toughness is only part of the Butyrate story. Sign manufacturers know that vacuum forming with Butyrate sheet is both quick and economical. Decorating may be done prior to or after forming, and there is no need to preheat the unformed sheet in special ovens. After forming, the Butyrate cools quickly; is ready almost immediately for subsequent fabricating or assembly operations. What's more, in-shop breakage is virtually eliminated because of the ability of this Eastman plastic to take abuse.

Next time you have a job that requires a truly tough, easy-to-form outdoor plastic material, use the plastic that makes the roughest duty routine—Tenite Butyrate. For further information on this versatile plastic, write EASTMAN CHEMICAL PRODUCTS, INC., subsidiary of Eastman Kodak Company, KINGSPORT, TENNESSEE.

TENITE®
BUTYRATE
an Eastman plastic



Centralab Ceramic-to-Metal Seals withstand 14,000 psi at 350°C*

The art of high temperature ceramic metalizing has been developed to new heights by CENTRALAB engineers. The most exacting tolerances can be readily achieved, as can the most permanent bond. Whether metalizing for the attachment of metal hardware or in preparation for hermetic sealing, CENTRALAB'S techniques will satisfy the most critical requirements.

* Temperature limits and tensile strength are functions of the geometry of the part and/or the melting point of the brazing alloy. Bond strengths are routinely achieved as high as 14,000 psi. This high temperature metalizing is a suitable base for silver solders, B-T brazing alloys, copper and many other metals. All seals are 100% tested on a mass spectrometer, with no leaks detectable to 2×10^{-10} cc/sec.

For additional technical data, write for CENTRALAB Bulletin EP-994.

Centralab

CRL

X-6042

The Electronics Division of Globe-Union Inc.
946J E. Keefe Ave. • Milwaukee 1, Wisconsin
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ELECTRONIC SWITCHES • VARIABLE RESISTORS • CERAMIC CAPACITORS • PACKAGED ELECTRONIC CIRCUITS • ENGINEERED CERAMICS

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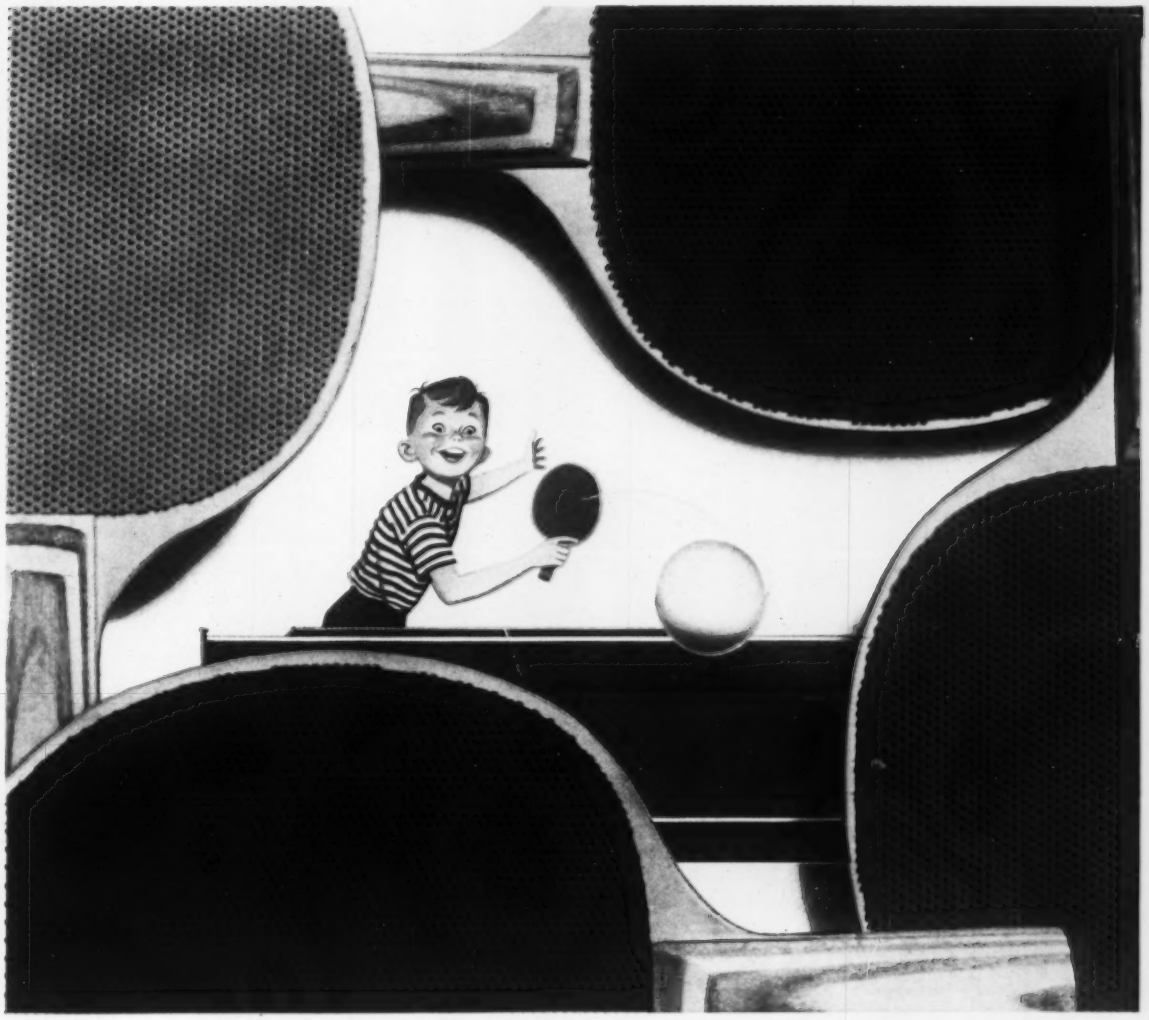


How Ameripol Rubber puts "English" on the ball

It takes a special rubber material to keep up with the table tennis trade. Those hundreds of tiny rubber nubbins on the paddle enable the player to put plenty of spin or "English" on the ball.

The manufacturer of this material, The Hodgman Rubber Company, turned to Ameripol Rubber to meet his unusual requirements. Since Ameripol 1013 is highly plastic in the processing stage, it proved to have ideal flow characteristics . . . thus a perfect molded pattern and strong bonding to the fabric backing was achieved. And with this light polymer, the material can be made in a variety of gay colors.

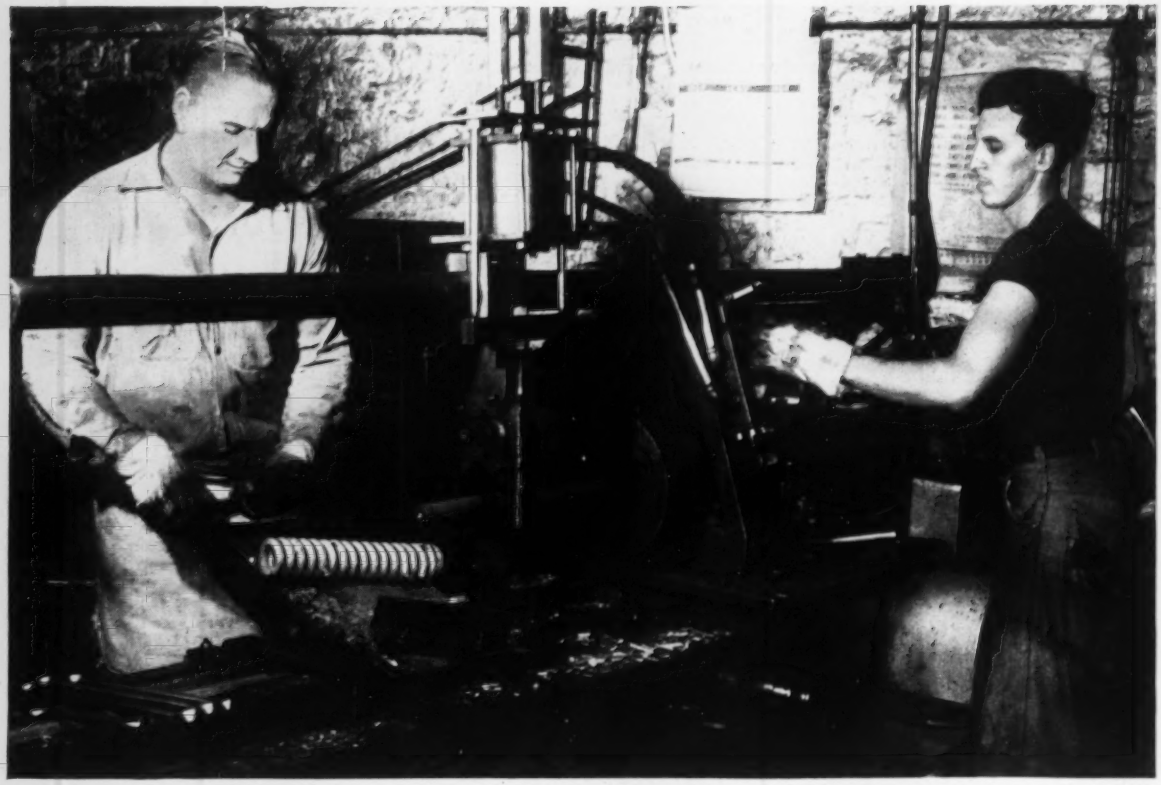
When you want to put something extra on the ball, check with Goodrich-Gulf. We produce the broadest range of rubber polymers in the industry, offer thorough technical service to match man-made rubber to your needs. For information contact Goodrich-Gulf Chemicals, Inc., 1717 East Ninth Street, Cleveland 14, Ohio.

Ameripol

Goodrich-Gulf Chemicals, Inc.

THE ONE TO WATCH FOR NEW DEVELOPMENTS

For more information, turn to Reader Service card, circle No. 379



What every designer should know about

High nickel alloy hot wound springs for high temperature service

For high temperature service in nuclear power plants, steam turbines and boilers, petrochemical plants and other industrial applications, large compression springs are needed. They can be hot wound from rod $^3/_8$ inch in diameter — or larger.

Resistance to relaxation at temperatures up to 1000 F plus economy are the most important factors in such service. From these overall standpoints and for corrosion resistance, Inconel "X"* nickel-chromium alloy is perhaps the most practical metal for hot wound springs:

- **It can be direct age hardened (16 hours at 1350 F) for useful service at temperatures up to 1050 F. Or down to −320 F — or lower.**
- **It has outstanding resistance to corrosion or oxidation . . . is especially resistant to strong oxidizing acids . . . has excellent resistance to alkaline corrosives.**
- **In the large rod sizes used for hot coiling, it actually costs less than many other high temperature spring materials.**

Inconel "X" alloy is easily worked, too. An Inconel "X" spring can be hot set and then age hardened . . . will respond consistently to the heat treatment, with practically no distortion.

Additional Alloys for Hot Wound Springs

"K" Monel* alloy — a non-magnetic nickel-copper alloy with strength and hardness comparable to heat-treated alloy steels. Its corrosion resistance and ductility are similar to those of Monel* nickel-copper alloy.

Duranickel* — an age-hardenable Nickel which can be treated after machining and forming. Highly corrosion-resistant . . . stronger and harder than "K" Monel alloy . . . often used for plastic extrusion equipment.

Helpful new Technical Bulletin T-35, "High Nickel Alloy Helical Springs," gives detailed design, fabricating and specifying information on Inconel "X" alloy, Duranickel, "K" Monel alloy and other useful age-hardenable materials for hot wound springs. It's yours for the asking. *Inco trademark

HUNTINGTON ALLOY PRODUCTS DIVISION
The International Nickel Company, Inc.
Huntington 17, West Virginia

INCO TRADE MARK **ALLOY PRODUCTS**

For more information, turn to Reader Service card, circle No. 396

THERMOFORMING . . . Pull-down of vacuum form occurs at about 375°F. Operator is shown stamping serial number on cover half during cooling cycle.

FINISHING . . . After trimming, rubber shock strips are applied with epoxy adhesive. Flame treating oxidizes and prepares desired surfaces for adhesive.

ASSEMBLING . . . Hardware is mounted and finished cover inspected. Notice circular base with perforated desiccant container.

PACKING . . . at Aerojet-General, thrust chambers are protected for shipment. Protective covers remain on until firing.

Rocket Engine Covers Thermoformed from MARLEX* Sheet

This unique packaging item, made by Thermo-Plastic Products Company of San Carlos, California, protects the first- and second-stage thrust chambers of the Titan missile during missile assembly and shipment . . . right up to actual firing. Initially, these covers were glass fiber laminate. Now, using MARLEX 6002 High Density Polyethylene, Thermo-Plastic does the job at considerably less than the previous cost—providing lightweight covers with high impact strength . . . free from warpage and cracking . . . and chemically resistant to fuels, lubricating oils, greases, solvents, alkalies, detergents, and most acids.

This rocket engine cover is a good example of what can be done as a result of the superior thermoforming characteristics of sheet made of MARLEX. Here, Thermo-Plastic draws to a maximum depth of 22 inches the 54" x 48", 230-mil sheet supplied by Kal Western Plastics, Inc., Pico Rivera, California. Cover halves and circular bases are separately formed, yet mate perfectly when assembled to provide a gasket seal against moisture.

If you are interested in heavy-duty, large or small shipping containers . . . or such items as tote boxes, refrigeration liners, dome covers, trays, any item involving the structural forming of sheet—MARLEX can be your answer for improved quality at less cost. Thick and rigid, thin and flexible, large or small, the superior physical characteristics of MARLEX sheet permit precision thermoforming to accurate dimensional tolerances. Moreover, there are many MARLEX resins to choose from—providing a wide range of material properties.

For complete details on thermoforming and a list of MARLEX sheet suppliers near you . . . contact one of the offices listed below.

*MARLEX is a trademark for Phillips family of olefin polymers.

For more information, circle No. 439

PHILLIPS CHEMICAL COMPANY, Bartlesville, Oklahoma, a subsidiary of Phillips Petroleum Company

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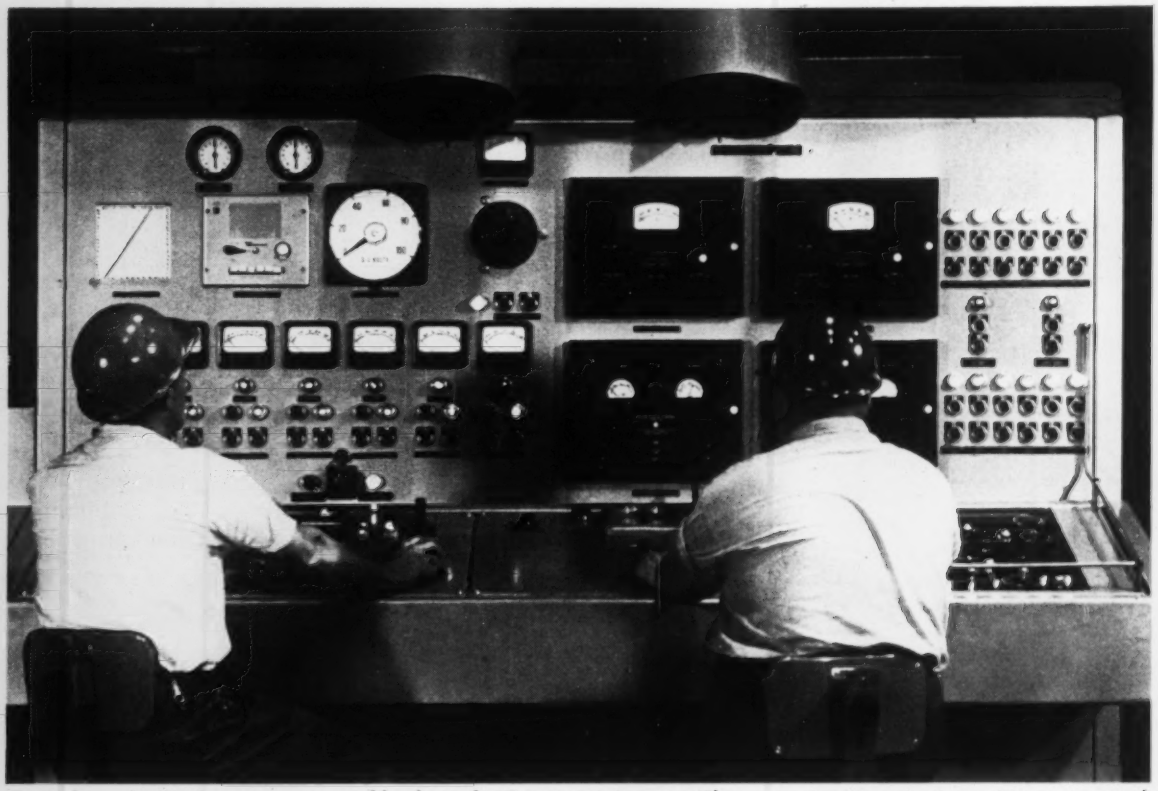
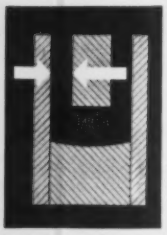
EXPORT: PHILLIPS PETROLEUM INTERNATIONAL CORPORATION • P. O. Box 7239, Panama City, Panama • Sumatrastrasse 27, Zurich 6, Switzerland

PHILLIPS 66 MARLEX PLASTICS



Control panel of a Carpenter consumable electrode (Consumet) furnace. Electronic circuits maintain positive arc control and precise electrode movement to assure the ultimate in refining.

Where *Carpenter's* "big inch" makes a mile of difference in alloy quality



The "big inch" in Carpenter's consumable electrode (Consumet®) furnace is the extra space between the consumable electrode and the mold wall. (Conventional furnaces of this type are almost ⅓ smaller at this vital point.) The "big inch" in Carpenter's furnace provides more exhaust space to carry off harmful gases. It also gives Carpenter technicians more precise vacuum control during the arc strike as well as during the entire melting process. As a result, you get cleaner, more uniform alloys from core to surface. Segregation and variation in grain size are minimized . . . to assure you consistent, predictable performance from your vacuum melted alloys. The "big inch" is only one of many exclusive Carpenter quality controls in consumable electrode, MEL-TROL® and vacuum-induction-melted (VacuMeltrol®) specialty steels. Ask your Carpenter representative for the full story behind these alloys and how they benefit you.

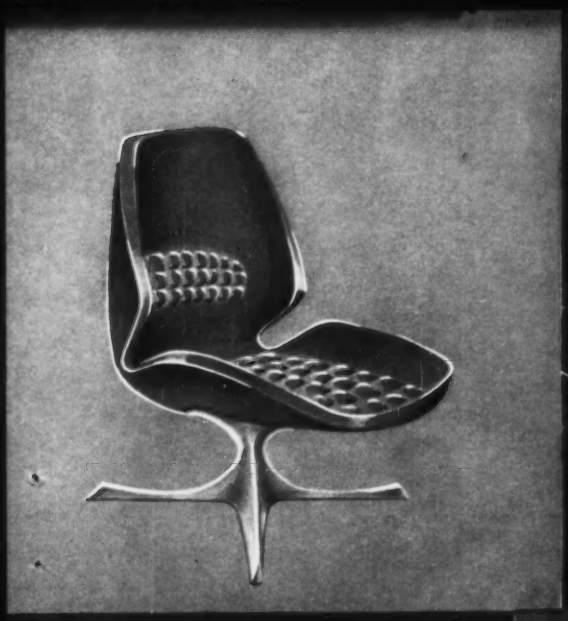
Carpenter steel

you can do it ***consistently*** better with Carpenter Stainless Steels for specialists

The Carpenter Steel Company, Main Office and Mills, Reading, Pa.
Alloy Tube Division, Union, N. J.
Webb Wire Division, New Brunswick, N. J.
Carpenter Steel of New England, Inc., Bridgeport, Conn.

For more information, turn to Reader Service card, circle No. 490

For more information, circle No. 475



Shape your product future with U.S. Royalite®

ABS THERMOPLASTIC SHEETS

Here is a versatile thermoplastic sheet material that forms to *any* shape in sharp detail – and still answers the basic design problems of toughness, beauty and economy. Used as a tool for advanced thinking, U.S. Royalite makes new, modern product designs practical. Check these advantages: (1) Royalite is extra tough to resist hard knocks and scrapes, is impervious to grease and oil, nonrusting and unaffected by most chemicals.* (2) Royalite molds cleanly, without seams or sharp edges to snag or chip. (3) Royalite gives you new textured beauty in a wide range of colors built in to last. (4) Royalite is extra light, making portable products even more portable. (5) Royalite is economical to use. Advanced fabricating techniques permit its wide use on popular-priced items. Send for free, file-size specifications booklet.

Two of many current applications of U.S. Royalite

ROYALITE PLASTIC PRODUCTS

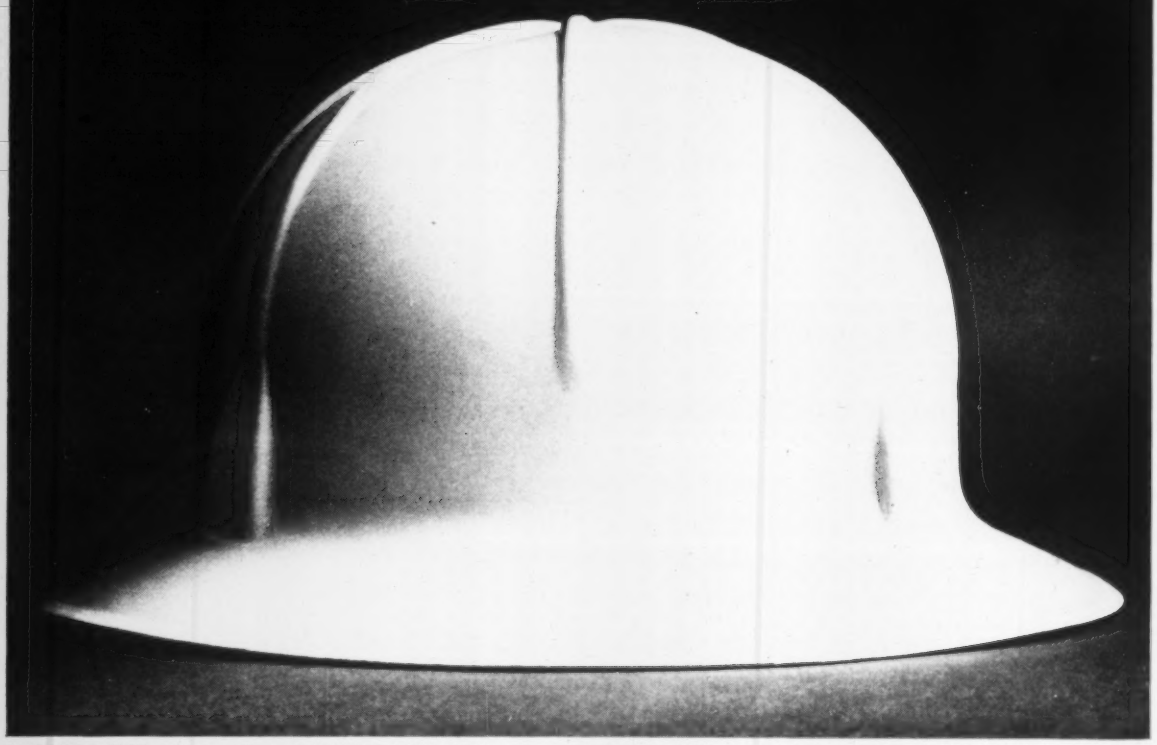
United States Rubber

2674 North Pulaski Rd., Chicago 39, Illinois

THINK POLYESTER RESINS! THINK **LAMINAC®** THE PIONEER POLYESTER!

■ Ease of fabrication in unusual shapes ■ Corrosion-resistance ■ High strength with low weight ■ Excellent electrical properties ■ Low tooling costs ■ Below are just a few of the 22 standard formulations of Laminac® Polyester Resins. Reinforced plastics with Laminac have been replacing wood and steel in countless areas since 1942 – when American Cyanamid pioneered the reinforced plastics field. Whatever *your* needs, there is a formulation of versatile Laminac specially compounded to solve your problems. For more information, write us today.

FITS ANY ENGINEER'S SPECIFICATIONS



LAMINAC 4107. Outstanding chemical-resistant resin; high reactivity; suitable for compression molding; especially suited for chemical tanks, exhaust systems and other equipment.

LAMINAC 4103. Medium reactive resilient resin for craze-free moldings; ideal for molded parts required to withstand heavy mechanical abuse, such as auto bodies, carrying cases.

LAMINAC 4152. An outstanding resin for spray gun applications; rapid cure; unexcelled strength properties in laminates with chopped glass fibers; for use in boats, swimming pools, other large structures.

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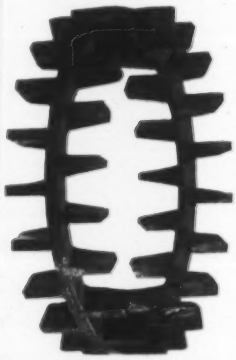

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COPPER #623
GENERAL PURPOSE

Ideal for shops with varied operations. Gives full or semi-bright plate on zinc base die castings, steel, brass or bronze.

EASY-TO-USE—A single addition agent for rack or barrel plating. Easily controlled for desired brightness level.

HIGHLY ECONOMICAL—Use as semi-bright at half the cost of full bright solutions.

VERSATILE—Easily buffed to cover wheel marks. Also brightens well in areas not easily accessible to buffing. Use in rack or barrel plating operations.

ISOBRITE®
COPPER #625
BUFF BRIGHT

Produces a very soft plate for quick buffing.

A COMPLETELY ORGANIC SYSTEM—No metallic constituents.

VERY ECONOMICAL—Works well over wide variations of temperatures and concentrations.

EXCELLENT FOR STOP-OFF—Produces plate that resists penetration by heat-treating or case hardening.

VERSATILE—Use in cyanide solutions with or without tartrates, Rochelle salts or proprietary substitutes.

These Isobrite Copper Processes contain no lead and are ready to work as soon as current is turned on, even after week-end shut downs. This means increased production and substantial savings by eliminating poorly plated rejects.

Auxiliary Addition Agents for Added Efficiency and Economy

ISOBRITE #630	Aids anode corrosion for greater efficiency and produces finer grained deposits.
ISOBRITE #631	Chrome reducer. Wide range of operation. Forms no undesirable breakdown products.
ISOBRITE #627-W	Wetting agent. Non-ionic surface agent with low-foaming action.
ISOBRITE #628-W	High detergency type wetting agent for severe organic contamination. All our wetting agents are easily cleaned from parts to give good nickel adhesion.

See your Allied Field Engineer for complete information and recommendations for the specific process that best meets your requirements. He's listed under "Plating Supplies" in the yellow pages. Or, write for FREE TECHNICAL DATA FILES.

Allied Research Products, Inc.

4004-06 EAST MONUMENT STREET • BALTIMORE 5, MARYLAND
BRANCH PLANT: 400 MIDLAND AVENUE • DETROIT 3, MICHIGAN
West Coast Licensee for Process Chemicals: L. H. Butcher Co. • European Agent: Stora Granbergar, Storgatan 10, Stockholm, Sweden

Chemical and Electro chemical Processes, Anodes, Rectifiers, Equipment and Supplies for Metal Finishing

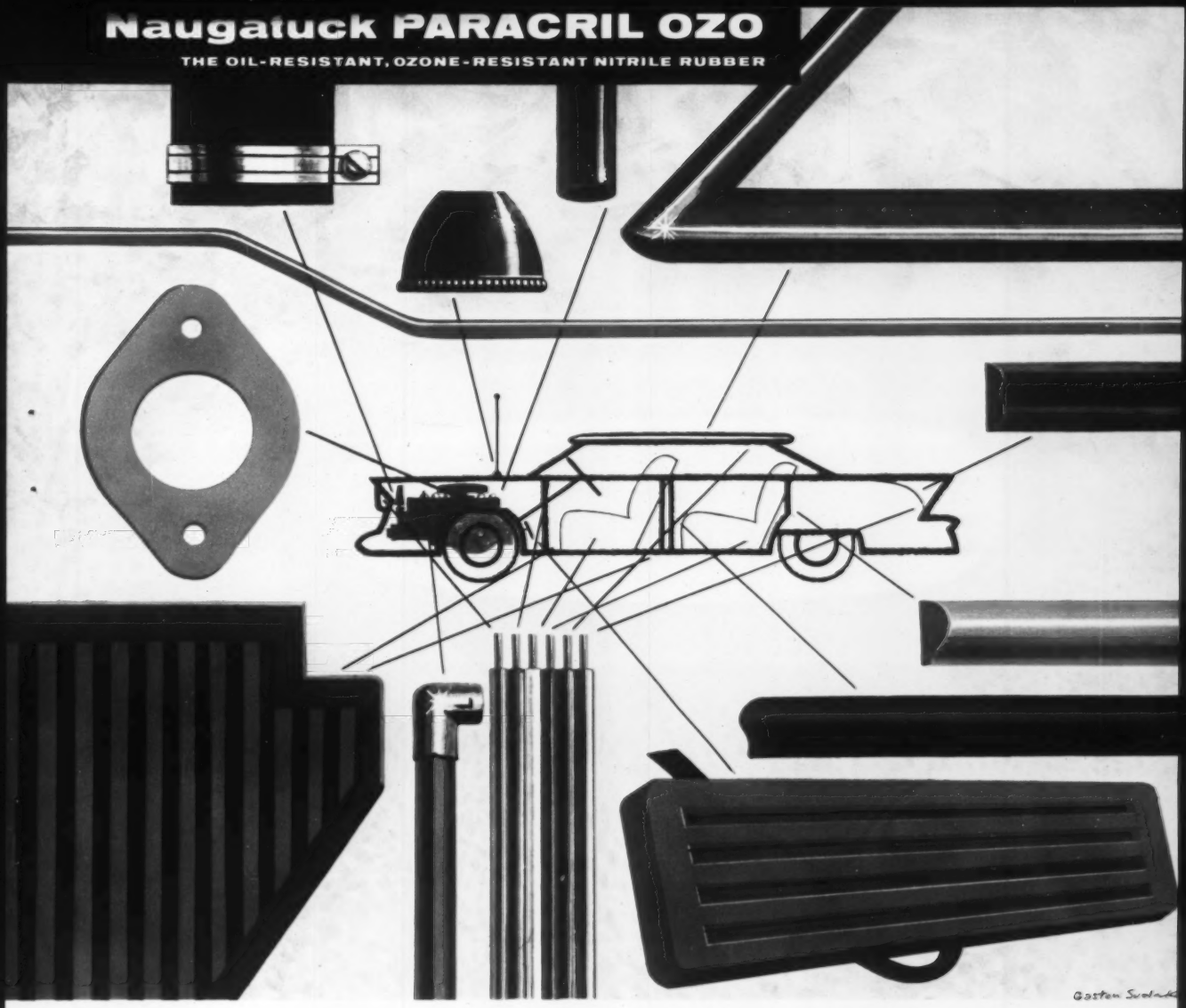
IRIDITE® Chromates | IRILAC® Coatings | ISOBRITE® Brighteners | ARP® Supplies | WAGNER Equipment

For more information, turn to Reader Service card, circle No. 324

For more information, circle No. 424

Naugatuck PARACRIL OZO

THE OIL-RESISTANT, OZONE-RESISTANT NITRILE RUBBER



Great new advance in automotive rubber

Here is a new rubber that's unmatched for oil, weather, and abrasion resistance. It's new PARACRIL® OZO, the finest achievement yet in the nitrile rubber field. PARACRIL OZO's properties are tailor made for many modern automotive parts—for everything from weather stripping to oil seals and hose. PARACRIL OZO gives you a whole series of important advantages, including:

- significantly superior ozone resistance
- excellent fuel and oil resistance
- several times greater abrasion resistance
- permanent retention of bright colors for exterior styling and easily traceable wiring and other interior parts

Look into PARACRIL OZO. Discover for yourself its new design possibilities...its unlimited color...its high quality. Contact your nearest Naugatuck representative at the address below.

Naugatuck Chemical

Division of United States Rubber Company Dept. A Elm Street Naugatuck, Connecticut

US RUBBER

Rubber Chemicals · Synthetic Rubber · Plastics · Agricultural Chemicals · Reclaimed Rubber · Latices · CANADA: Naugatuck Chemicals Division, Dominion Rubber Co., Ltd., Elmira, Ontario · CABLE: Rubexport, N.Y.

The seams don't show

Beautiful fit, beautiful look, beautiful soft drink dispenser. Beautiful job of close tolerance molding by General American. Working from wooden patterns, General American engineers designed six individual moldings. The shrinkage of each separate part was calculated to the thousandths of an inch. General American made the tools with the same precision.

Result—when this soft drink dispenser is assembled the seams are practically unnoticeable. In addition, the selection of the proper plastic, combined with General American's skill in molding, provides a product with very good luster, high impact properties, excellent stain resistance—and a reasonable price tag.

If you have a part or product that could or should be made of plastics, consult General American. In plastics, *it pays to plan with General American.*

in this 6-piece soft drink dispenser

GENERAL AMERICAN TRANSPORTATION CORPORATION

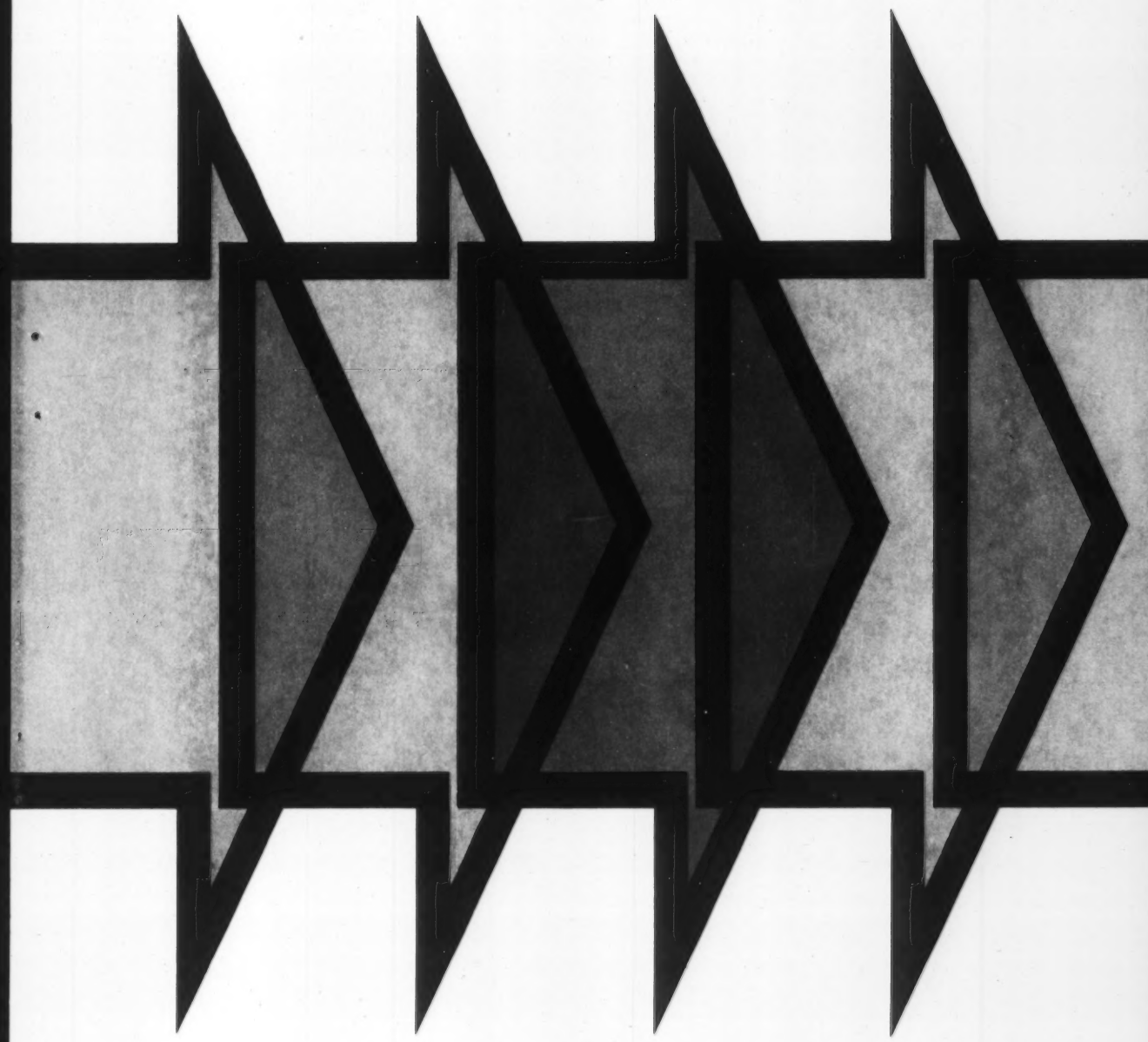
135 South LaSalle Street • Chicago 3, Illinois

Offices in principal cities

PLASTICS DIVISION GENERAL AMERICAN TRADE MARK

For more information, turn to Reader Service card, circle No. 376

For more information, circle No. 384



FROM GREAT LAKES STEEL

15 X-A-R 30

ABRASION RESISTANT STEELS

TWO NEW STEELS—HARDER FOR HARDER JOBS

X-A-R

ABRASION RESISTANT STEELS

HARD ENOUGH AND TOUGH ENOUGH TO LAST

Is abrasion your constant enemy? If your equipment meets materials as they're scooped, shoved, slid, pushed, dragged or dumped, does it face the recurring threat of downtime for repairs or replacement? To eliminate such maintenance headaches, Great Lakes Steel has developed two tougher, harder alloy steels—X-A-R 15 and X-A-R 30. They're supplied in hardnesses from 360 to 400 BHN (or, by agreement, in a range of hardness between 265 and 500 Brinell). And they're especially effective and economical in those critical bear-the-brunt areas of the equipment where wear is worst—liners, teeth, bars, blades and plates, for example. *Under conditions that commonly wear out equipment in a hurry, X-A-R abrasion-resistant steels outwear any other type of steel.*

Great Lakes Steel is a division of

WHERE MATERIALS COLLIDE WITH EQUIPMENT

Chemical composition alone is not the secret of low carbon X-A-R steels; their balanced combination of uniformity, high strength, hardness and toughness is the result of close control during heat-treating, quenching and tempering. This makes them more workable, too. Under normal welding and fabricating conditions use X-A-R 30. For *extremely* difficult problems, such as welding under cold conditions or extensive flame cutting, choose X-A-R 15.

X-A-R abrasion resistant steels are immediately available in ⅛" to 1" thicknesses, widths up to 72" and lengths up to 35'. For technical information and supply sources, see next page.

X-A-R

A PRODUCT OF

GREAT LAKES STEEL

Detroit 29, Michigan

NATIONAL STEEL CORPORATION

15 X-A-R 30

TECHNICAL INFORMATION

CHEMICAL COMPOSITION

X-A-R steels are furnished at two specified carbon ranges. These are 14 to 20 carbon for X-A-R 15 and 25 to 30 carbon for X-A-R 30. The balance of the typical composition is:

Manganese	.80%	Chromium	.65
Phosphorous	.020	Molybdenum	.20
Sulphur	.028	Zirconium	.06
Silicon	.60		

TYPICAL MECHANICAL PROPERTIES

	At Brinell Hardnesses of: 363	400
Tensile Strength, psi	180,000	200,000
Yield Strength, psi	165,000	180,000
% Elongation in 2"*	17	16
% Reduction in Area*	56	55
Charpy V Impact at —75°F.	12 (Ft. Lbs.)	7

*Based on standard .505" specimen

ENGINEERING DATA

Resistance to Atmospheric Corrosion (Rural, Marine, and Industrial Environments)	3-5 times copper-bearing or carbon constructional steel
Compressive Yield Strength, psi	Approx. equal to Tensile Yield Strength
Ultimate Shearing Strength, psi	Approx. equal to Tensile Yield Strength
Modulus of Elasticity, psi	29/30,000,000
Endurance Limit (rotating beam)	60% of Tensile Strength
Coefficient of Expansion per °F.	70°F. to 200°F.—.0000062

FABRICATION

Cold Bend Test: Moderate bending can be performed within the usual range of hardnesses. For free bending, it is recommended that a mandrel be used not less than ten times the thickness of the metal through an angle of 90°.

Welding: Low hydrogen electrodes are recommended for welding X-A-R steels. The grade of electrode used is dependent on the strength requirement of the weldment.

Burning: X-A-R steels can be flame cut without pre-heating or stress relieving after cutting.

COMPLETE METALLURGICAL SERVICE

In addition to the information given in this folder, there is a great deal of detailed data available to steel users covering all characteristics of X-A-R steels. Furthermore, a thoroughly competent metallurgical service organization is available to work with you on any application problem you may have.

X-A-R STEELS ARE AVAILABLE AT THESE STEEL SERVICE CENTERS

BENEDICT-MILLER
Lyndhurst, New Jersey

JOSEPH DEMSEY COMPANY
Cleveland, Ohio

DUCOMMUN METALS & SUPPLY COMPANY
Los Angeles, California

INTERSTATE STEEL COMPANY
Evanston, Illinois

LOCKHART IRON & STEEL COMPANY
Pittsburgh, Pennsylvania

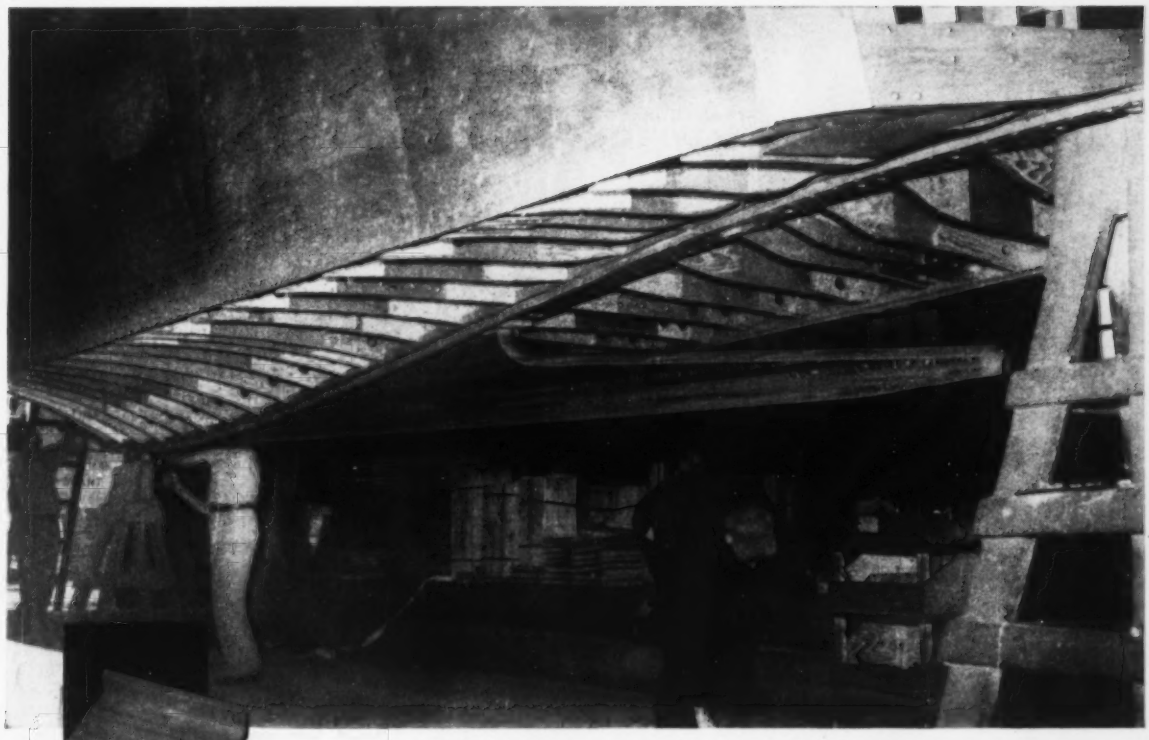
MARSH STEEL & ALUMINUM COMPANY
Kansas City, Missouri

O'NEAL STEEL, INCORPORATED
Birmingham, Alabama

SALT LAKE HARDWARE COMPANY
Salt Lake City, Utah

A. C. LESLIE & COMPANY, LIMITED
Montreal, Canada

15 X-A-R 30
ABRASION RESISTANT STEELS



from dishwasher tops... to barge skegs...

GAMBLE solves problems with WOOD!

PROBLEM: Wood cutting-board tops of automatic dishwashers were splintering—and even distorting the machines themselves—from tangential swelling and shrinking of the tops.

SOLUTION: Gamble wood engineers developed a strip-constructed board, with edge grain exposed, which is now in volume use.

PROBLEM: The solid wood skegs (outer keel) of assault barges were cracking and splitting on beach landings.

SOLUTION: The *first* laminated skeg was researched and developed—then built in quantity—by Gamble Brothers.

Design problems like these are "all in a day's work" to the wood engineers at Gamble Brothers —a unique organization designing and building a wider variety of wood products than any other U. S. woodworking company. Today they're working in three principal areas: (1) improvement of present wood products (2) development of new wood products (3) product development in combinations of wood and other materials.

Why not present *your* design or component problem to Gamble Brothers? WOOD may be the answer!

FREE booklet illustrates GAMBLE services

This 28-page booklet describes Gamble facilities and services in detail. Includes many photographs of unusual products designed, tested and perfected by Gamble Brothers. Write for your copy today! Gamble Brothers, Inc., 4627 Allmond Ave., Louisville, Ky.

If the problem involves wood, Gamble can help!

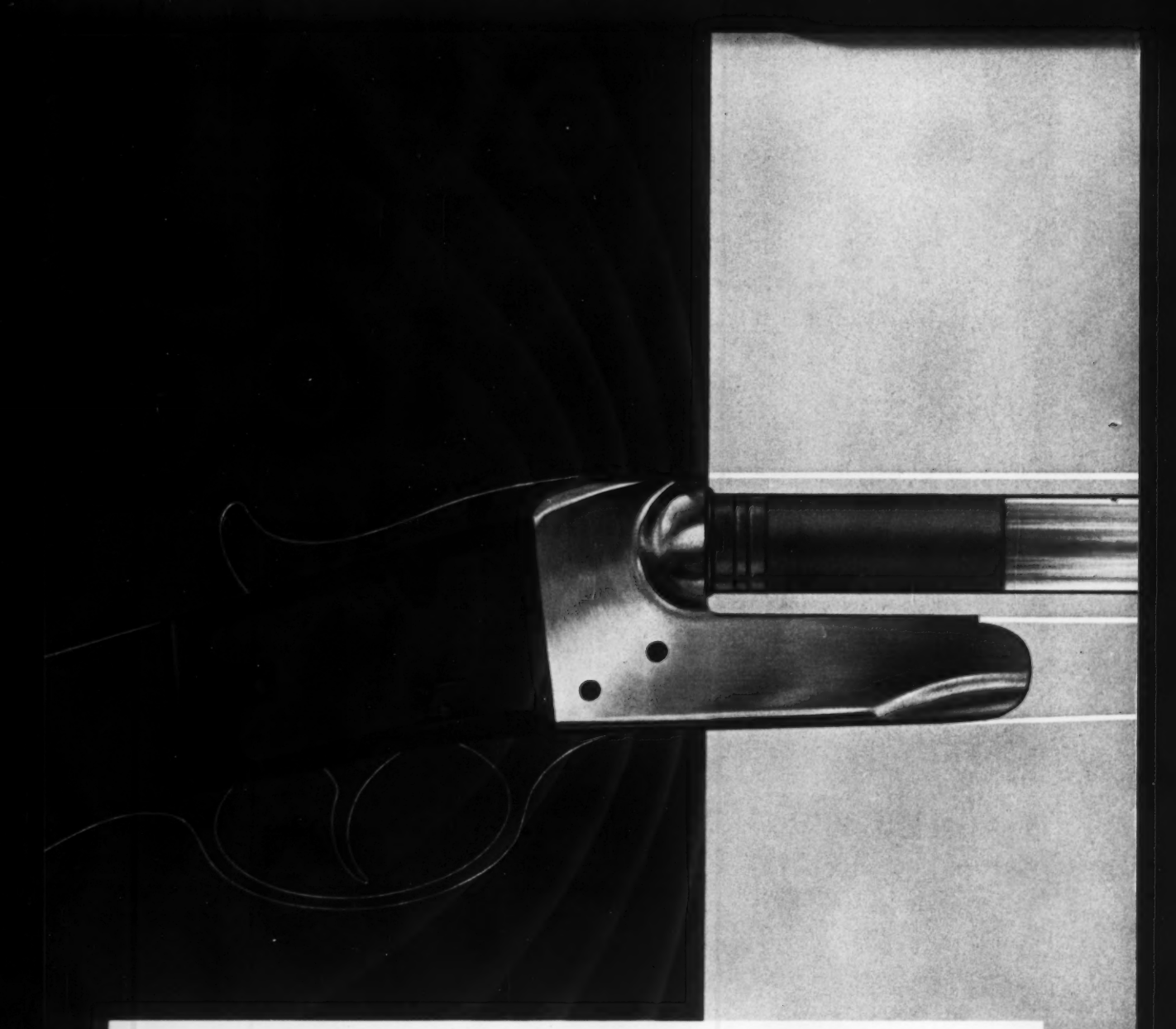
GAMBLE BROTHERS GB GUARANTEED BOND

GAMBLE BROTHERS, INC.

4627 Allmond Avenue, Louisville, Kentucky

◀ For more information, circle No. 384

▲ For more information, turn to Reader Service card, circle No. 374



Pressure on the face of this Malleable iron receiver approaches 5 tons per square inch each time this 12 gauge shotgun is fired.

For Really Tough Parts...Use Malleable

With high powered charges being fired just inches from your face, you don't want parts that can't take it. That's why so many weapon parts are made of tough Malleable iron castings.

Tremendous resistance to impact, fatigue, deflection, and wear also makes Malleable castings favorites among manufacturers of mining and construction equipment, heavy-duty tools, and other products that require extra tough components.

Have you investigated how Malleable castings will improve your product's performance and cut costs at the same time? If not, send drawings or outline of your requirements to a nearby Malleable castings producer who displays this symbol —

MEMBER

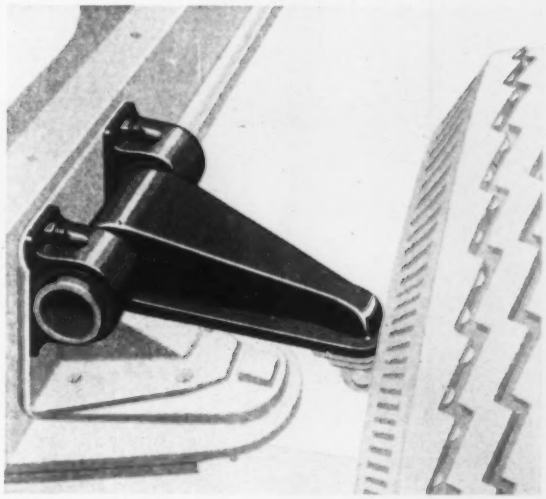
MALLEABLE CASTINGS COUNCIL

For detailed information on "Toughness", contact any of the progressive companies listed on the opposite page, or Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.

Malleable Assures Toughness and Dependability for Torsion Arms

Torsion arms are the vital link between the violent motion of the wheels and the resisting force of torsion bars. Tough, dependable Malleable iron castings are used for torsion arms by every manufacturer of vehicles that employ torsion bar suspension systems. Malleable castings take this kind of punishment without failure.

First, Malleable's modulus of elasticity provides the rigidity necessary to resist deflection under heavy loads. Second, Malleable castings' high ratio of yield to tensile guarantees plenty of reserve strength, even for torsion arms on trucks used continuously for off-the-road service.



Tensile Properties—A.S.T.M. Minimum Specifications Standard and Pearlitic Malleable Irons

Designation	Tensile Strength p.s.i.	Yield Strength p.s.i.	Elongation % in 2 in.
Standard			
35018	53,000	35,000	18
32510	50,000	32,500	10
Pearlitic			
45010	65,000	45,000	10
45007	68,000	45,000	7
48004	70,000	48,000	4
50007	75,000	50,000	7
53004	80,000	53,000	4
60003	80,000	60,000	3
80002	100,000	80,000	2

Strengths up to 135,000 p.s.i. tensile and 110,000 p.s.i. yield are produced commercially under individual producers' specifications.

Other Mechanical Properties Standard and Pearlitic Malleable Irons

	Standard	*Pearlitic*
Modulus of Elasticity in Tension, p.s.i.	25,000,000	25,500,000—28,000,000
Ratio of Fatigue Strength to Tensile Strength	0.54	0.40—0.50
Shear Strength—% of Tensile Strength	80—90%	70—85%
Torsional Strength	Approximately equal to Tensile Strength	
Compressive Strength, p.s.i.	200,000	250,000

In addition to their proven toughness and stamina, Malleable castings are outstanding for manufacturing economy. Modern casting methods produce parts so close to finished shape that surplus metal is reduced to the minimum. Malleable saves time and tools in machining because no material of comparable properties machines so easily and quickly.

FREE ENGINEERING GUIDE

A condensed synopsis of engineering data plus case histories that may suggest ways for you to improve your products is available from any member of the Malleable Castings Council, or from the Council's offices, Union Commerce Building, Cleveland 14, Ohio. Just ask for *Data Unit No. 105, "Toughness."*

For Quality and Economy... Use MALLEABLE

For Service In Your Area Contact...

CONNECTICUT
Connecticut Mall. Castings Co., New Haven 6
Eastern Malleable Iron Co., Naugatuck
New Haven Malleable Iron Co., New Haven 4

DELAWARE
Eastern Malleable Iron Co., Wilmington 99

ILLINOIS
Central Fdry. Div., Gen. Motors, Danville
Chicago Malleable Castings Co., Chicago 43
Moline Malleable Iron Co., St. Charles
National Mall. and Steel Castings Co., Cicero 50
Peoria Malleable Castings Co., Peoria 1
Wagner Castings Company, Decatur

INDIANA
Albion Malleable Iron Company, Muncie Division, Muncie
Link-Belt Company, Indianapolis 6
National Mall. & Steel Castings Co., Indianapolis 22

IOWA
Iowa Malleable Iron Co., Fairfield

MASSACHUSETTS
Belcher Malleable Iron Co., Easton

MICHIGAN
Albion Malleable Iron Co., Albion
Auto Specialties Mfg. Co., Saint Joseph
Cadillac Malleable Iron Co., Cadillac
Central Fdry. Div., Gen. Motors, Saginaw

MINNESOTA
Northern Malleable Iron Co., St. Paul 6

MISSISSIPPI
Mississippi Malleable Iron Co., Meridian

NEW HAMPSHIRE
Laconia Malleable Iron Co., Laconia

NEW YORK
Acme Steel & Mall. Iron Works, Buffalo 7
Frazer & Jones Company Division Eastern Malleable Iron Co., Solvay
Oriskany Malleable Iron Co., Inc., Oriskany
Westmoreland Mall. Iron Co., Westmoreland

OHIO
American Malleable Castings Co., Marion
Central Fdry. Div., Gen. Motors, Defiance
Dayton Mall. Iron Co., Ironton Div., Ironton
Dayton Mall. Iron Co., Ohio Mall. Div., Columbus 16
Maumee Malleable Castings Co., Toledo 5
National Mall. and Steel Castings Co., Cleveland 6

PENNSYLVANIA
Buck Iron Company, Inc., Philadelphia 22
Erie Malleable Iron Co., Erie
Lancaster Malleable Castings Co., Lancaster
Lehigh Foundries Company, Easton
Meadville Malleable Iron Co., Meadville
Pennsylvania Malleable Iron Corp., Lancaster

TEXAS
Texas Foundries, Inc., Lufkin

WEST VIRGINIA
West Virginia Mall. Iron Co., Point Pleasant

WISCONSIN
Belle City Malleable Iron Co., Racine
Chain Belt Company, Milwaukee 1
Federal Malleable Company, Inc., West Allis 14
Kirsh Foundry Inc., Beaver Dam
Lakeside Malleable Castings Co., Racine
Milwaukee Malleable & Grey Iron Works, Milwaukee 46

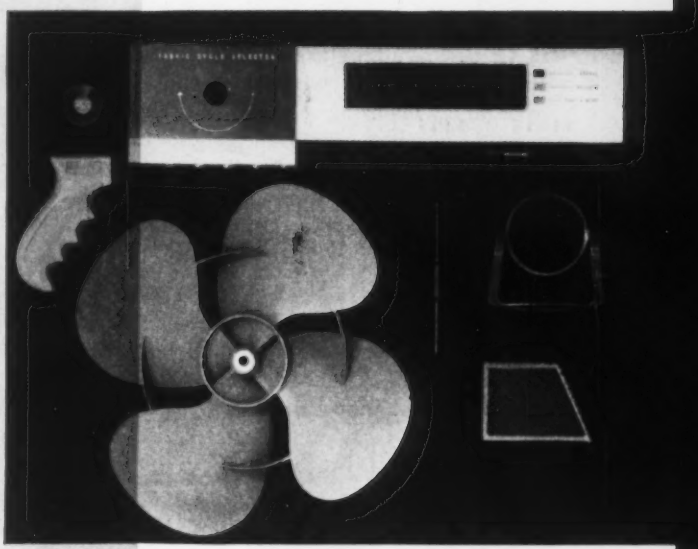
For more information, turn to Reader Service card, circle No. 520

How the custom molder can help bring your product idea to life

The custom molder is well-known as a mass producer of molded plastics parts and products. But he is much more. Most helpful to the designer, the custom molder knows the design limits of the different plastics. He can recommend the best formulation for the job. He can also engineer the design to capitalize on the inherent advantages of plastics materials and the efficiencies of plastics manufacturing. His toolmakers build the master molds to the closest tolerances. His productive facilities can turn out plastics parts with unusually consistent quality, at rates to meet the tightest schedules and budgets.

Monsanto keeps the custom molder supplied with molding formulations of Monsanto Polyethylene, Lustrex® Styrene, and Opalon® Vinyl, specially developed and constantly perfected to meet a wide range of design requirements.

Which molding compounds to consider? Use the Plastics Properties Calculator, an easy-to-read slide rule that provides comparative property data on the many different plastics molding materials. For your free calculator, write to Monsanto Chemical Company, Plastics Division, Room 732, Springfield 2, Mass.



MONSANTO PACE-SETTER IN **PLASTICS**

Monsanto

For more information, turn to Reader Service card, circle No. 499

GRAPHITAR®

(CARBON-GRAPHITE)

THE VERSATILE ENGINEERING MATERIAL THAT POSSESSES MANY UNIQUE AND PRACTICAL ADVANTAGES FOR A VARIETY OF APPLICATIONS

MINIMUM LUBRICATION REQUIRED—Because of the controlled porosity and non-melting nature of GRAPHITAR, the only lubricant GRAPHITAR bearings need is water or other low-viscosity fluid. Any such fluid with non-gumming characteristics will provide an extremely low coefficient of friction and assure long life of the GRAPHITAR parts.

RESISTANCE TO CHEMICAL ATTACK—GRAPHITAR has the ability to withstand the action of almost any chemical, with the exception of the most highly oxidizing re-agents in hot and concentrated form. GRAPHITAR parts, for example, operate efficiently in steam, chemical and gas valves to provide a corrosion resistant material operating under the most adverse conditions.

MECHANICALLY STRONG—GRAPHITAR will not warp or distort even in high pressure applications. Compressive strength up to 45,000 psi and transverse breaking strength from 3000 to 16,000 psi, depending on the grade.

HEAT RESISTANT—GRAPHITAR is not affected by heat under neutral or reducing conditions. Temperatures of oxidation for most grades is approximately 700 degrees F. In addition, GRAPHITAR engineers have developed a special oxidation resistant grade of GRAPHITAR that has been exposed in an oxidizing atmosphere (air) of 1200 degrees F. and after 200 hours, it showed a weight loss of less than six per cent.

MOLDABLE—GRAPHITAR has excellent moldability properties that make possible and practical unusual shaped parts. Design requirements such as ears, face slots, and outside diameter notches can easily be incorporated into GRAPHITAR parts without secondary machining and finishing operations.

MACHINING—The United States Graphite Company operates an excellent finishing department to do all finishing operations to the most exacting specifications. GRAPHITAR may be ground to size or shaped with a tungsten carbide or diamond tipped tool to tolerances as close as .0005". When surfaces require a high degree of precision in flatness, lapping and polishing equipment are employed and accuracies within three light bands can be produced.

LIGHT WEIGHT—GRAPHITAR is lighter than magnesium and is being employed increasingly in the aircraft and missile fields. The weight per unit volume of various GRAPHITAR grades is as follows: 102.8 to 116.03 pounds per cubic foot, .0595 to .0672 pounds per cubic inch, .952 to 1.074 ounces per cubic inch.

Write today for Engineering Bulletin No. 20

R-284-1

THE UNITED STATES GRAPHITE COMPANY

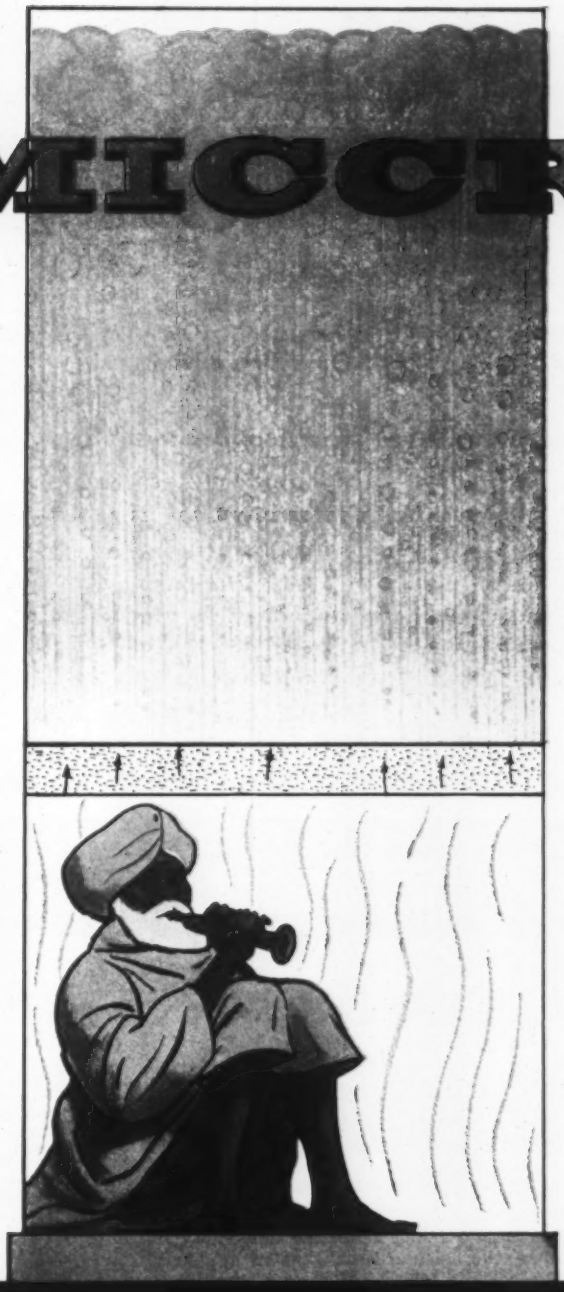
A DIVISION OF THE WICKES CORPORATION, SAGINAW 3, MICHIGAN

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDER METALLURGY • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES

For more information, turn to Reader Service card, circle No. 502

Our laboratory magic brings you

MICCRON



POWDERED PLASTIC RESINS

for Fusion Coating . . . giving you

- **New design opportunities**
- **Sales appeal; with exciting, colorful new finishes**
- **Industrial corrosion and/or insulation protection**
- **Drip- and sag-free films**
- **Sharp edge coverage**
- **Wide ranges of materials in: Vinyls, Cellulosics, Epoxies, and Nylons**

Miccron Resins give you the physical and chemical advantages of these plastics in colorful, attractive coatings; applied by flocking, spraying, or the fluidized-bed process.

A six-page brochure, describing Miccron Resins and their application, is yours for the asking. Write us on your company letterhead for the good news on these new, revolutionary coatings.

We'll look forward to hearing from you.

MICHIGAN CHROME *and Chemical Company*

8615 Grinnell Avenue, Detroit 13, Michigan

MICCRO Products

For more information, turn to Reader Service card, circle No. 414

For parts DIRECT from machining to assembly..dependably

NO HEAT TREATING REQUIRED with

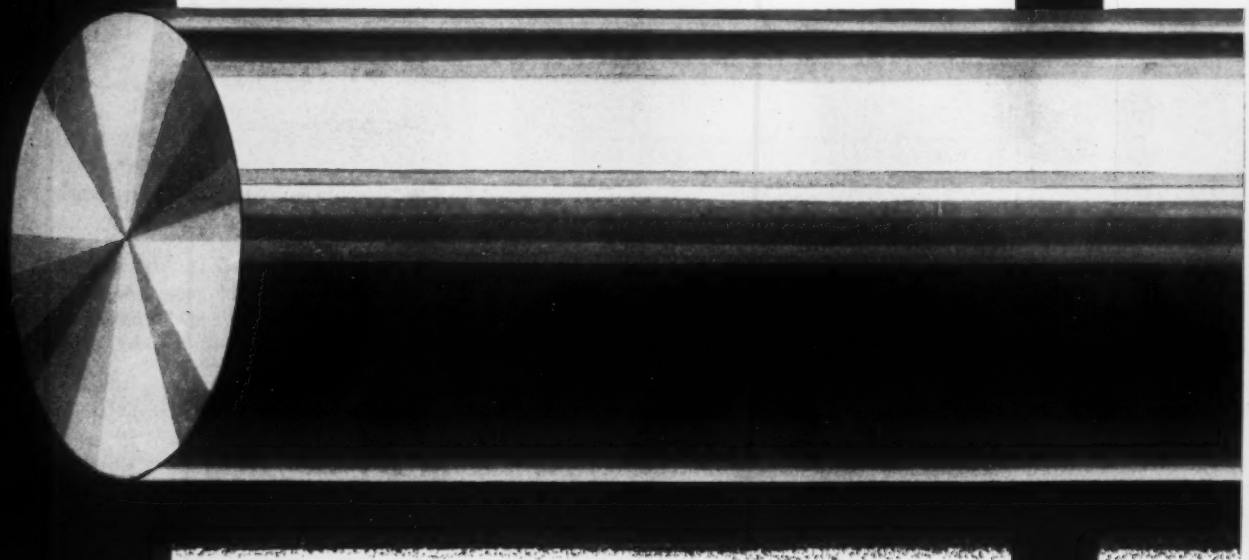
La Salle e.t.d. 150

elevated temperature drawing

ALLOY STEEL BARS

GUARANTEED 150,000 PSI tensile strength

- e.t.d. 150 alloy machines better than heat treated in-the-bar alloy steels!
- e.t.d. 150 alloy has exceptional uniformity!
- e.t.d. 150 alloy simplifies production!



Quality and Cost-reducing Advantages!

(1) Heat treating with its attendant costs and hazards is eliminated. (2) No quench cracks or distortion due to heat treating. (3) Machinability is greatly improved by the acicular pearlitic-ferritic structure. (4) Tool life and finish are excellent. (5) Production is simplified . . . secondary operations following heat treat are eliminated. (6) Part quality, uniformity and reliability are maintained or improved. (7) End cost is greatly reduced.

Ask for a sample test bar

Send a blueprint . . . or write us giving application details.

What is e.t.d. 150 alloy?

"e.t.d." 150 is an alloy steel bar made by the exclusive and patented Elevated Temperature Drawing process to a guaranteed minimum tensile strength of 150,000 psi and a hardness of Rc 32 minimum. Strength and hardness are uniform across the section of the bar. The uniform pearlitic-ferritic structure of "e.t.d." 150 alloy eliminates the problems associated with non-uniform quenched and tempered structure. Ideal for shafts, gears, pinions, fasteners and other parts now being heat treated or made from heat treated in-the-bar materials.

SPECIFICATIONS

Ultimate Tensile Strength	150,000 psi minimum*
Yield Strength (.2% offset)	130,000 psi minimum*
Proof Stress (.01% offset) (1½" Rd. and smaller only)	120,000 psi minimum*
Elongation—Approx. only	10% -20%
Reduction of Area—Approx. only	35% -45%
Brinell Hardness Number	302 minimum*
Rockwell "C" Hardness	32 minimum*

*GUARANTEED MINIMUMS. In event of disagreement between hardness and tensile strength, the tensile strength shall govern.

Use this coupon to ask for helpful data bulletin

La Salle STEEL CO.

1418 150th Street
Hammond, Indiana

Please send Helpful Data Bulletin No. 22, "e.t.d. 150 alloy steel bars eliminate heat treating of parts."

Name_____

Title_____

Company_____

Address_____

City_____ Zone____ State_____

For more information, circle No. 403

AT HOME IN THE ATOMIC AGE...

Matter of fact, stainless steel is more at home in these demanding times than ever before. Rigid requirements in modern components—rather than restricting the use of stainless—have opened an even broader market for this versatile metal. Its remarkable durability and superior resistance to corrosion and heat make stainless all but indispensable in the construction and operation of atomic energy plants. Eastern is proud to have a share in this vital activity.

Eastern is the world's largest exclusive producer of stainless steel sheets and plates. Sold through steel service centers coast to coast.

EASTERN
STAINLESS STEEL
BALTIMORE 3, MARYLAND, U.S.A.
Stainless steel sheets, plates, strip, coils

Above: Schematic drawings show how nuclear fission occurs. One atom becomes two, releasing energy.
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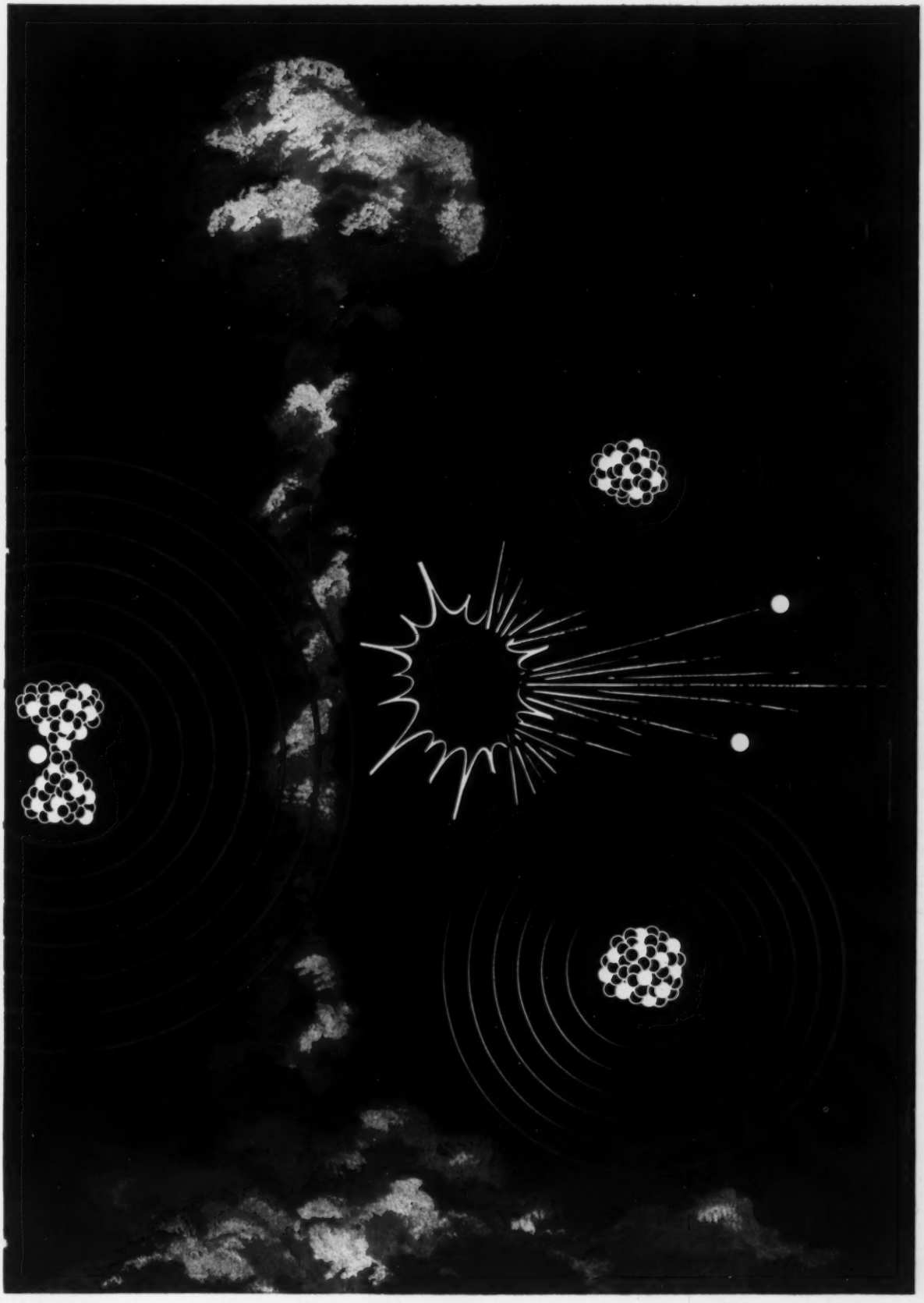


For more information, turn to Reader Service card, circle No. 361

ENJAY BUTYL

IS TOPS IN ALL-'ROUND

RESISTANCE TO CHEMICALS

Enjay Butyl, because of its unique and extremely low degree of unsaturation, offers excellent resistance to corrosive chemicals. The preferred rubber for tank linings, hose, seals, gaskets and other applications where exacting chemical resistance is required.

VIVID COLORS

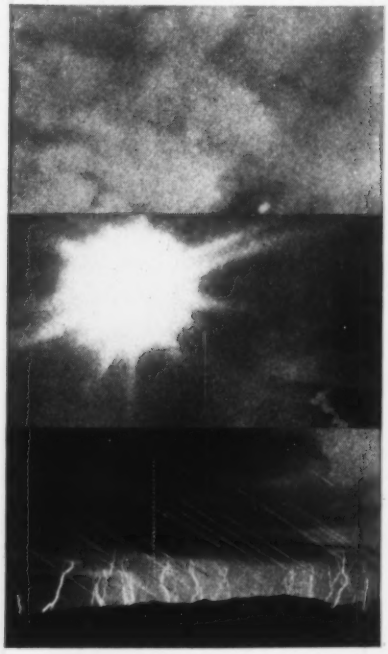
Enjay Butyl requires no additives for quality coloring over a wide range of hues. Famous for colorability and smooth finishes, Butyl has been successfully plastic coated for special applications.

RESISTANCE TO TEAR AND ABRASION

Enjay Butyl offers the highest aged tear strength of any rubber . . . even after long exposure to ozone and heat! Its inherent toughness resists abrasive wear, in such applications as tires, conveyer belts, hose and other mechanical goods.

RESISTANCE TO SUN-LIGHT AND WEATHERING

Enjay Butyl has proven its resistance to ultra-violet light, ozone, oxidation, moisture and mildew. Increases life of products such as weatherstrips, garden hose, wading pools and automotive parts.



RUBBER
PERFORMANCE

DAMPING PROPERTIES

Enjay Butyl absorbs shock and vibrational energy more completely than any other rubber. Resiliency can be varied in compounding and processing. Butyl is ideal for axle and body bumpers, motor mounts and sound-deadening applications.

IMPERMEABILITY TO GASES AND MOISTURE

Enjay Butyl is tops in impermeability to gases and moisture . . . retains air pressure 8 times better than natural rubber. Outperforms other rubbers in such application as inner tubes, jar and bottle seals, hoses and inflatable goods.

ELECTRICAL RESISTANCE

Enjay Butyl tops all vulcanizable rubbers in electrical and dielectric properties . . . in resistance to corona and ozone breakdown and water absorption. Its high dielectric strength insures against electric breakdown under normal or surge voltage. Its heat resistance permits higher current flow for a given conductor size.

The outstanding properties of Butyl Rubber create new horizons for the designer, and offer to manufacturers an opportunity to utilize the qualities of rubber in applications never before possible. The unique properties of Butyl have led to vast improvement in many existing products. Technical skills will open the way to countless new uses.

Butyl is the "idea" rubber with uses stretching as far as the imagination can reach. We'll be glad to tell you all about it. Just contact the nearest Enjay office.

EXCITING NEW PRODUCTS THROUGH PETRO-CHEMISTRY

ENJAY CHEMICAL COMPANY

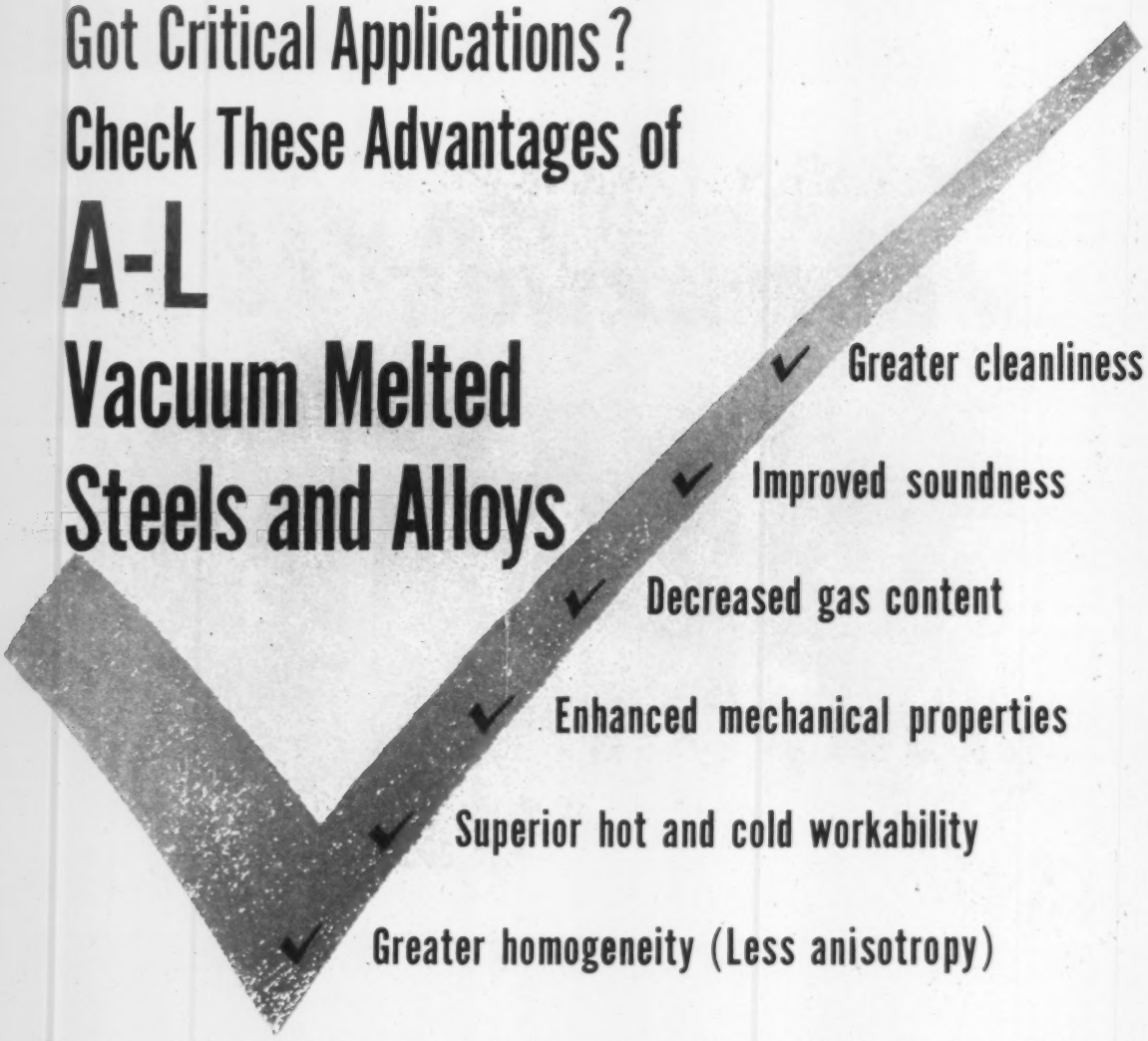
A DIVISION OF HUMBLE OIL & REFINING COMPANY

HOME OFFICE: 15 West 51st Street, New York 19, N. Y. OTHER OFFICES: Akron • Boston • Charlotte • Chicago • Detroit • Houston • Los Angeles • New Orleans • Tulsa

ENJAY® BUTYL

For more information, turn to Reader Service card, circle No. 365

Got Critical Applications? Check These Advantages of A-L Vacuum Melted Steels and Alloys



✓ Better quality in the finished part, properties to withstand severe manufacturing processes, fewer rejections—these are some of the cost savings of vacuum melted materials from Allegheny Ludlum.

A-L vacuum melted steels and alloys are specified for really critical applications—places where their improved metallurgical and mechanical properties get a chance to go to work. Aircraft and missile designers find vacuum melted alloys especially useful in solid fuel rockets, and in the missile and jet engine fields. Other important uses are critical parts for machinery and chemical processing equipment.

Low alloy steels, bearing steels, stainless steels, and high temperature alloys all take on new value when vacuum melted at Allegheny Ludlum. These steels and alloys are available in all commercial mill forms—plates, sheets, strip, billet, bar, wire, tubes, and even extrusions.

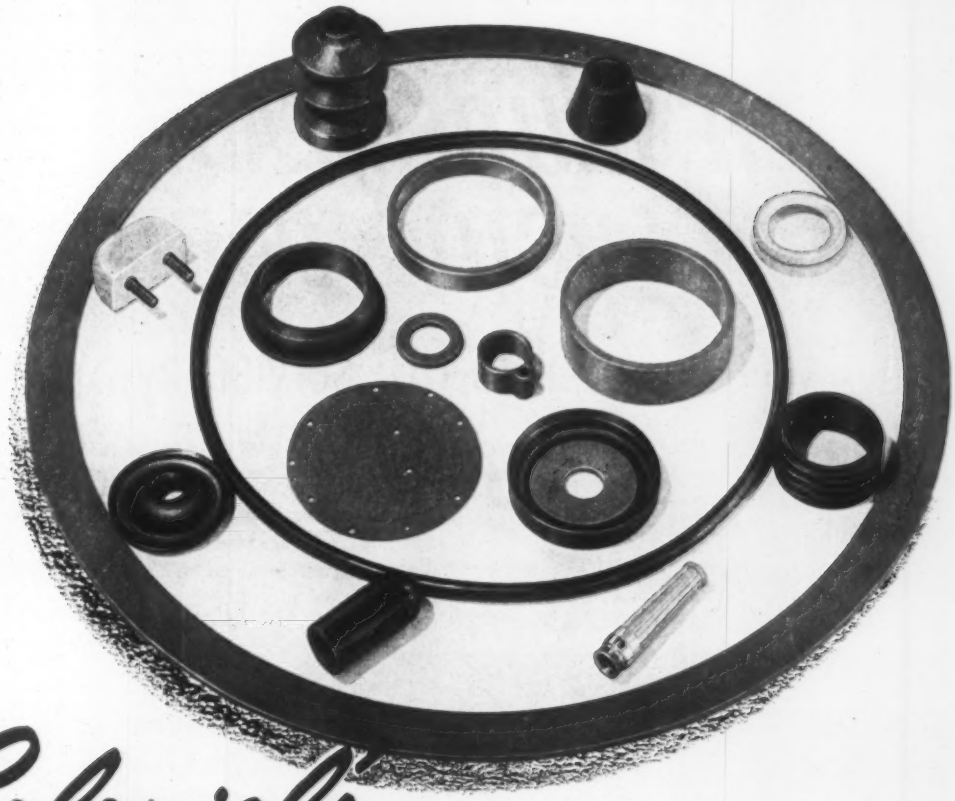
Three different vacuum melting processes are used at A-L to provide you with the exact properties you need at the lowest possible cost. For more information on A-L's vacuum melting processes and their advantages, write for your copy of the new booklet, "Modern Melting at Allegheny Ludlum." It contains technical data on new melting techniques and the quality improvement in alloys. *Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pennsylvania. Address Dept.* MM-9.

ALLEGHENY LUDLUM

PIONEERING on the Horizons of Steel

2257

For more information, turn to Reader Service card, circle No. 322



Colonials

"SILICOL"® SILICONE RUBBER

can improve your product and simplify fabrication problems

★ ***ANY MOLDED SHAPE***

★ ***ANY COMPOUND FORMULATION***

Colonial Rubber has a long record of achievement in using the unique properties of silicone rubber to meet "tough service" applications in all types of manufacturing. Particularly outstanding are the many special compounds our chemists have formulated to meet unusually rigid performance requirements in aircraft and missile applications.

In addition to the comprehensive industrial rubber technology we offer to help manufacturers solve rubber compounding problems. Colonial has large, modern and complete plant facilities to assure lower cost rubber molding and fabricating. We are *known* for our ability to meet manufacturer's "emergency" delivery requirements on priority projects.

Save time on your programs by sending prints and pertinent data on your *first* inquiry. We will promptly return an analysis and recommendations, together with illustrated information giving you complete details on our organization and its ability to serve you efficiently and economically.

1718-A

COLONIAL RUBBER CO.

706 Oakwood St. AXminster 6-9611

RAVENNA, OHIO

For more information, turn to Reader Service card, circle No. 347

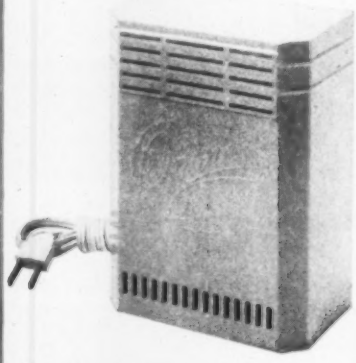
IF YOU'RE READY FOR CUSTOM PARTS

It pays to get complete QC* service by Sylvania

Sylvania helps you with completely objective recommendations for your parts. From long experience in metals, plastics, welds and assemblies Sylvania can take fullest advantage of a wide range of equipment.

Expert design assistance is available and can often improve the quality of your part and, more important, can often help lower the cost of production.

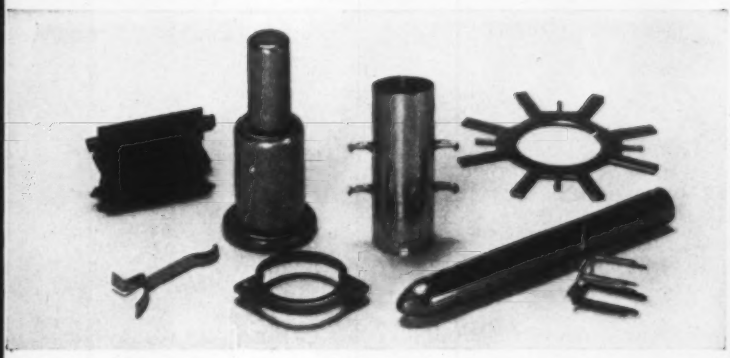
Outstanding quality parts come from the most modern equipment available plus long experience in tooling. In addition, Sylvania practices preventive maintenance for dies and equipment to assure precise uniformity and uninterrupted production.



CUSTOM ASSEMBLED

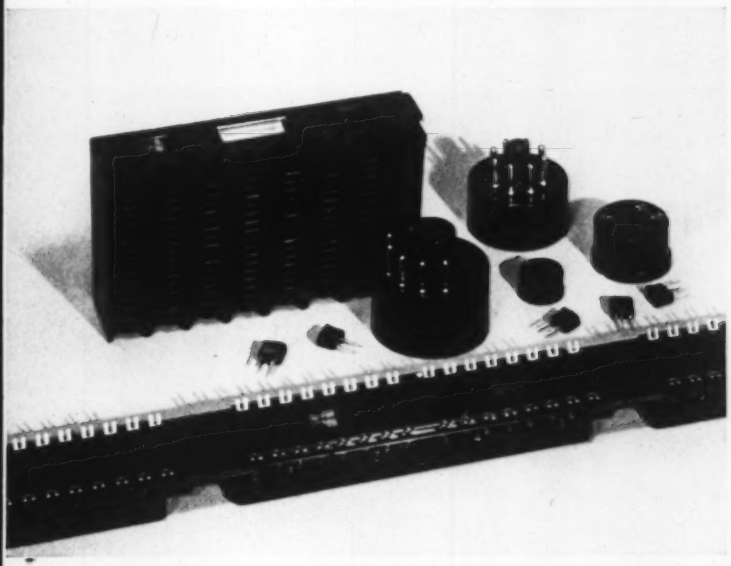
Many of our customers have found Sylvania can often assemble and package a product —at lower cost than they themselves—no matter who *makes* the parts. Subassembly work can also provide customers with additional and unexpected savings.

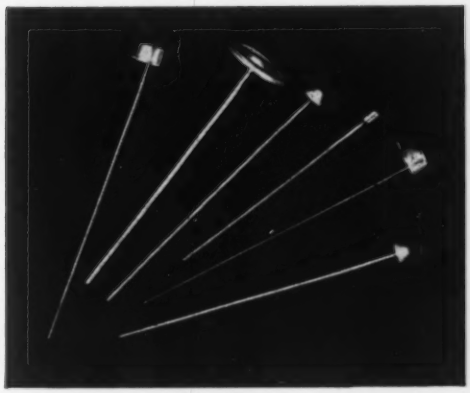
Result: If your product is small, the parts predominantly plastic and metal, and the quantities 50,000 or more, it pays you to have Sylvania trained specialists assemble it.



FORMED FROM METAL

Sylvania maintains complete custom metal stamping facilities and can produce millions of precision-made parts each day from most all types of metal. These parts are available in the desired high-production quantities—to the most exacting specifications—at low cost to you. Sylvania can produce deep-draw eyelet parts, shells, cups and ferrules. Our batteries of multi-slide equipment can produce more than 2 million parts daily. Vertical presses can meet daily production needs of 2 million parts. And special, Sylvania-developed machines can turn out great quantities of small wire and ribbon forms as well as wire cuts and leads.





CUSTOM WELDED

It makes no difference if your part is standard-sized, miniature or subminiature. Welded assembly is a Sylvania specialty. To help you meet your custom assembly needs, Sylvania has developed new high-speed, high-volume welding techniques, advanced welding equipment, automatic and semiautomatic, and a corps of trained specialists.

Results: Sylvania welded assemblies assure high-quality electrical and mechanical contact, mirror-image uniformity and low cost.

MOLDED FROM PLASTICS

Sylvania offers quick, efficient production of plastic parts—and at low piece prices in production quantities. Reason? Sylvania operates one of the most complete lines of modern automatic molding equipment in the world for compression, injection and transfer molding. Our bank of rotary presses can produce more than a million parts a day, is ideally suited to phenolics and urea, and assures minimum cost for simply designed plastic parts.

*QC MEANS QUALITY CONTROL!

Sylvania maintains a complete quality control department to assure that parts are made to your exact specifications. This control works for you throughout the manufacturing cycle. It's just one more way you benefit when you have Sylvania on the job for parts.

For full details or a quote, write Sylvania Electric Products Inc., Parts Division, Warren, Pennsylvania.

SYLVANIA

Subsidiary of **GENERAL TELEPHONE & ELECTRONICS**

For more information, turn to Reader Service card, circle No. 468

Joe Foster, President,
tells why Nylon-6 is one of the
great molding resins.

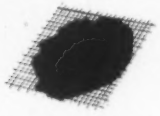
"There are four good reasons why Nylon-6 is one of the great molding resins," *says Joe Foster*

COLORABILITY

Fosta Nylon accepts a wide range of colors. To suit your manufacturing requirements, Fosta Nylon may be pigmented *during* formulation. Or, articles may be colored in water-soluble dyes *after* fabrication.

NON-FLAMMABILITY

Fosta Nylon is one of the few self-extinguishing materials and is ideal for use in portable electric appliance housings. Also, Nylon-6 provides good heat-resistance and good electrical properties.



EASE OF MOLDING

Higher melt viscosity of Fosta Nylon makes it easy to injection mold or extrude. Thick or thin cross-sections and large surface areas may be produced with greater ease than ever before.

STRENGTH

Fosta Nylon will resist severe impact and heavy stresses in all directions, even in thin sections. It has excellent wearing properties due to a low coefficient of friction and is resilient, recovering readily from deformation under load.

For more information, circle No. 372

IF DESIGN, development or marketing of profitable, efficient end products is your responsibility, you can't afford to overlook Fosta® Nylon's unique combination of advantages as a fabricating material.

One of the great molding resins, Nylon-6 lends itself to a wide-range of end products, including: portable electric appliance housings, drapery hardware, gears and football cleats. And, our customers' experience plus our own work as the world's largest manufacturer of sunglasses indicates there are countless other applications for this resin.

Its basic properties make us confident that versatile Nylon-6 has a wonderfully promising future. In addition to colorability, strength, non-flammability and ease of molding, Fosta Nylon also provides toughness, abrasion- and impact-resistance, flexibility, heat-stability and is self-lubricating. This is why Nylon-6 can do almost anything a molded product may require.

Still another product advantage is the magic name of "Nylon." Consumers everywhere know that a "Nylon" product is something special, is different from any other materials and possesses greater product features. You'll find the extra merchandisability of "Nylon" can add magic sales-power to all types of products.

As an incentive to make Nylon-6 a more widely used material, we recently reduced the price of Fosta Nylon to 98 cents a pound in quantity. Our confidence in Nylon-6 prompted this move.

To make Fosta Nylon more familiar to you, we would like to send you our current literature. Whatever your product design, development and marketing strategy, we'll be glad to demonstrate why Nylon-6 should be part of your thinking. Just call or write Foster Grant Co., Inc., Leominster, Mass., KEystone 4-6511. We're ready to work with you right now!

FG

FOSTER GRANT

Your Partner in Plastics Progress

Plants in Leominster, Mass.,
Manchester, N. H., Baton Rouge, La.
Branch Offices and Warehouses in principal cities

INTERLOX...

a better, lower cost, easily controlled phosphate coating that **LOCKS** *your finish to the metal.*

Interlox's unusual cleaning ability and radically different type of accelerator produce an even, fine grained, dense coating that literally locks an organic finish to the metal.

Interlox gives you the ultimate in appearance, adhesion and corrosion resistance—no streaks, stains, powdery residue or flash rusting to complicate your production. Interlox baths are unusually long lived and require less replenishment and control.

Extra cleaning power is easily obtained at any time by the addition of a low-cost detergent only. This avoids the danger of over-phosphatizing by the costly practice of adding complete phosphatizing compound when only cleaner is needed.

There is an Interlox product to meet your particular requirements, whether spray or immersion type, single or multiple stage.

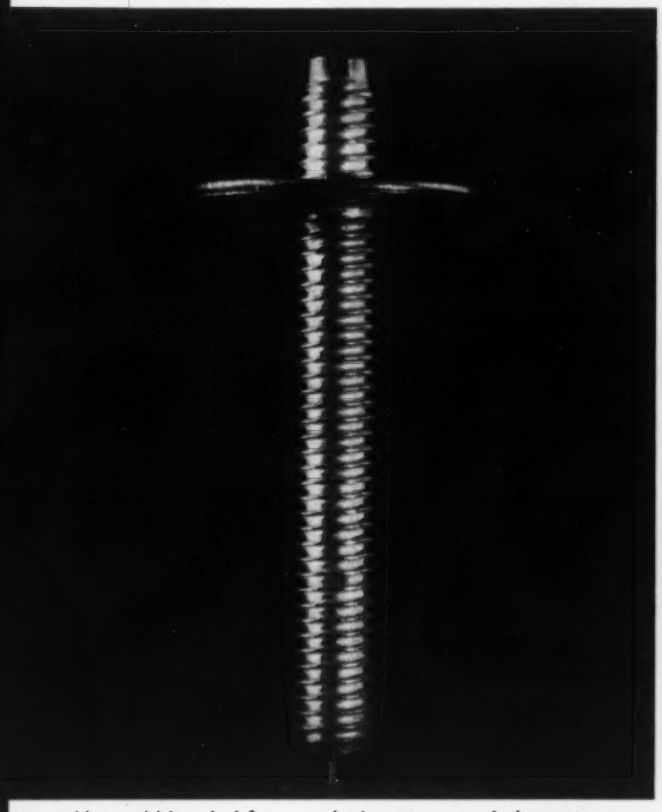
Licensed Manufacturers { **Alert Supply Co., Los Angeles, California**
Armalite Company, Ltd., Toronto, Canada

NORTHWEST CHEMICAL COMPANY

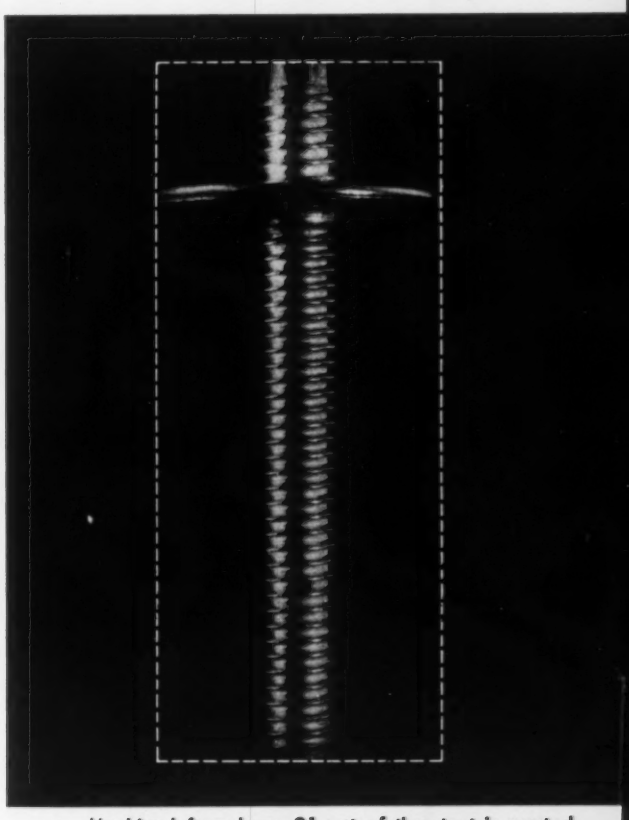
9310 ROSELAWN **DETROIT 4, MICHIGAN**

For more information, turn to Reader Service card, circle No. 426

This "impossible" screw is now being cold-headed



Now cold-headed from steel wire at one-tenth the cost.



Machined from bars, 91 pct of the steel is wasted.

This automobile window-adjusting channel screw is being produced from cold-heading wire at one-tenth the original cost. Formerly machined from bar stock with a 91 per cent waste, this special screw is upset to three-and-one-half times the diameter of its shaft.

Bethlehem Steel has played a vital role in the progress of cold-heading by supplying steel wire in the proper grades and analyses, and by recommending the correct heat-treatment.

You may now be machining parts that can be cold-headed, at less cost—and with improved properties. By no means do we say that we can supply cold-heading wire for every one of them. But our experienced metallurgists have helped many users of cold-heading wire to improve their results. Perhaps they can do the same for you. Our nearest sales office will welcome the chance to talk it over. Or get in touch with us at Bethlehem, Pa.

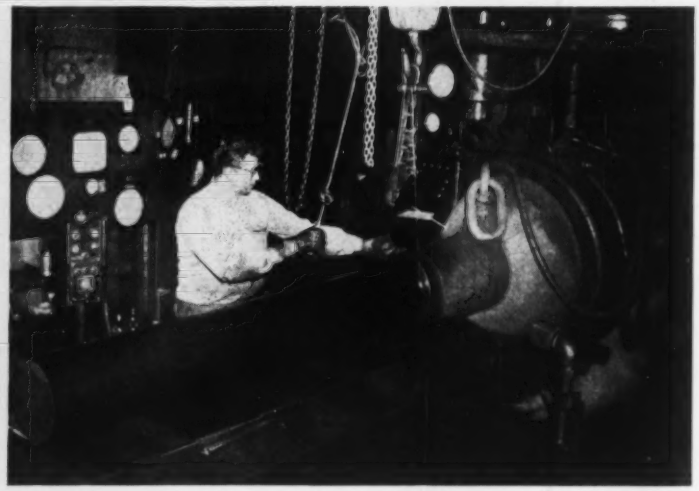
BETHLEHEM STEEL COMPANY, BETHLEHEM, PA. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

For more information, turn to Reader Service card, circle No. 509

HAVE YOU EXPLORED GRAPHITE As A Problem-Solving Material?



Are you looking for an economical substance that combines machineability, chemical inertness, high thermal conductivity, high temperature stability, resistance to thermal shock, corrosion resistance?

Are you looking for a material that has proved to be highly suitable for such diverse applications as vital nuclear reactor components, molds and dies for metals casting, sintering boats and trays, run-out tables and canisters, refractories, brazing fixtures, linings in chemical process equipment, thermocouple shields, and electric resistance furnace parts?

May we have the opportunity of helping you solve your materials design problem with some of the finest graphite being produced today by one of the largest graphite producers in the world?

PRODUCTS ELECTRODE GLC DIVISION YOU CAN TRUST ®

GREAT LAKES CARBON CORPORATION

18 EAST 48TH STREET, NEW YORK 17, N. Y. OFFICES IN PRINCIPAL CITIES

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ACCURATE PRENOTCHING OF ROLL FORMED SHAPES
cuts assembly costs
ROLL FORMED PRODUCTS CO
RF
Our accurate method of pre-notching, forming, and cutting your metal shapes and sections to lengths will reduce your costs.
Finished sections ready for final assembly can be delivered to meet your exact schedules.
Send us your prints and quantity requirements today.
Let us show you how our continuous pre-notching and forming operations can reduce your costs for special shapes and sections.
Do you have our catalog No. 1555?
SEE OUR CATALOG IN SWEET'S
ROLL FORMED PRODUCTS
COMPANY
3752 Oakwood Ave., Youngstown, Ohio

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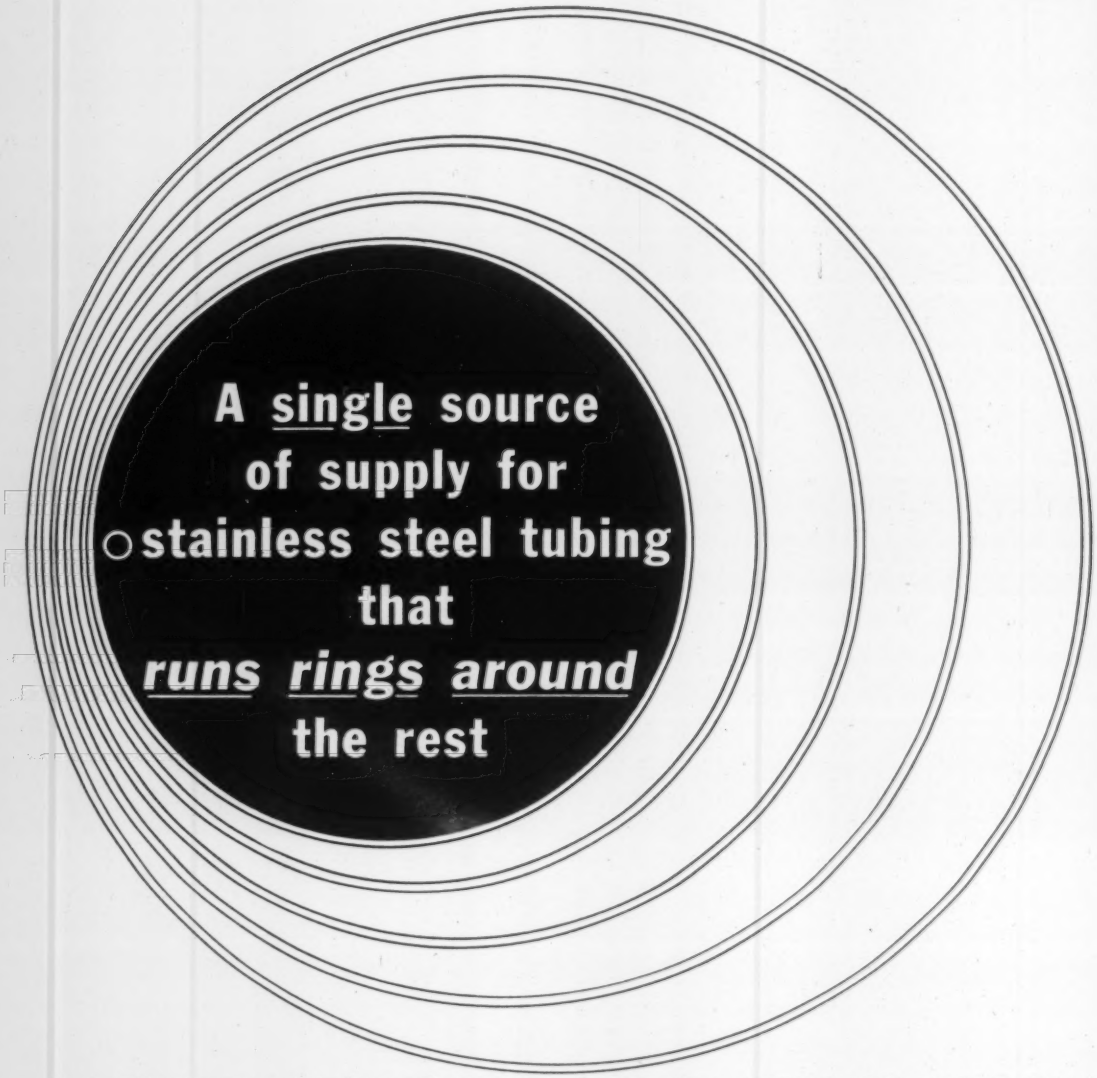


Widest range of fusion welded pipe and tubing available—bright annealed or pickled finishes.

Lengths up to 60 feet. ⅛″ to 6⅝″ O.D. Wall thickness from .008″ to .154″ depending upon O.D. and application.

For every need . . . aviation applications, ornamental, architectural, mechanical and high-temperature uses, pressure flow lines, sanitary processing . . .

And for quality assurance . . . complete X-ray, ultrasonic and Eddy Current equipment . . . tensile tests, automation gaging, laboratory samplings.

Why not purchase your stainless steel tubing and pipe where tonnage is produced on a laboratory basis? Write for new folder on stainless steel tubing.

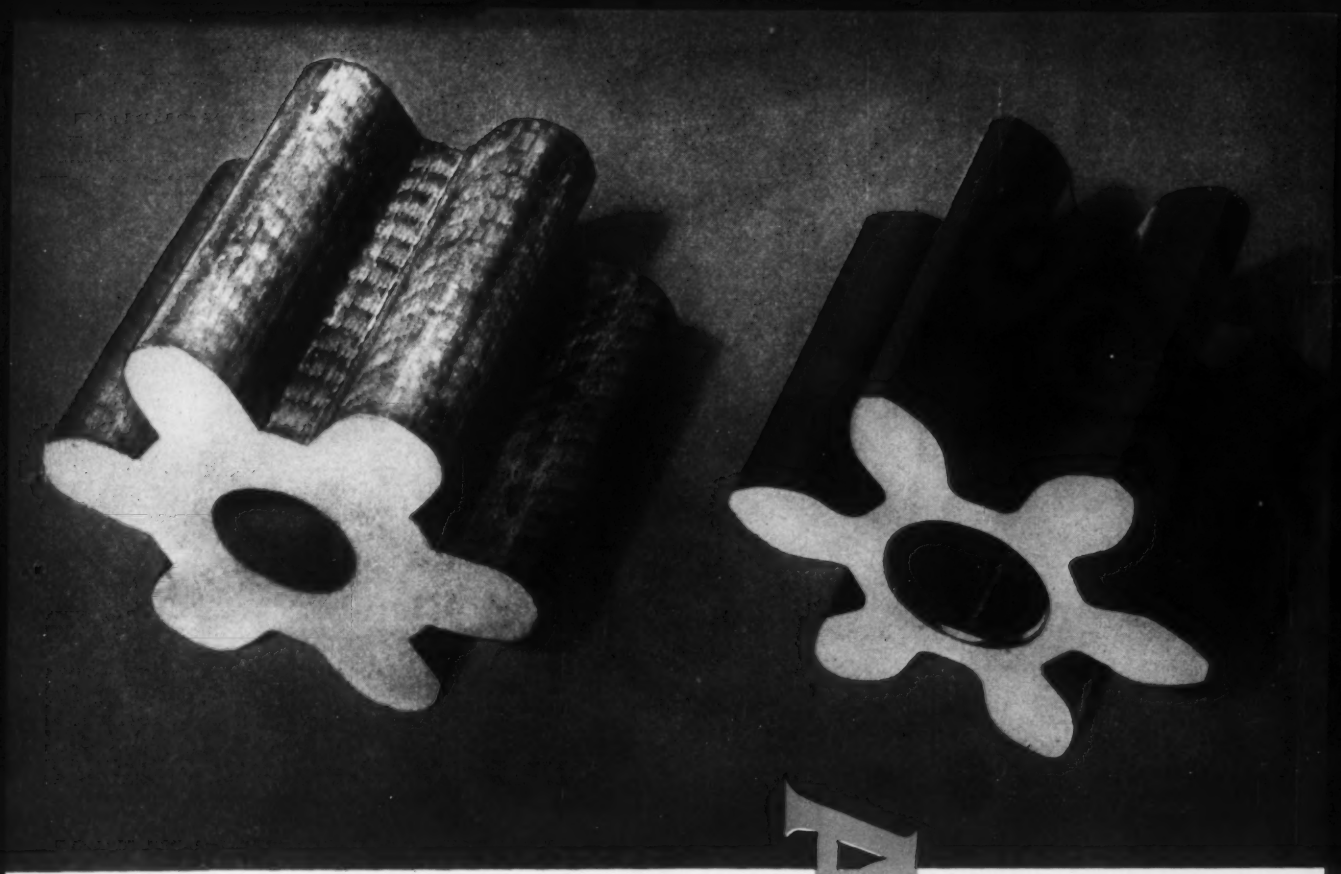
THE WALLINGFORD STEEL CO.

Progress in Metals for Over 38 Years

WALLINGFORD, CONN., U.S.A.

COLD ROLLED STRIP: Super Metals, Stainless, Alloy • **WELDED TUBES AND PIPE:** Super Metals, Stainless, Alloy

For more information, turn to Reader Service card, circle No. 514



Custom shapes in continuous lengths:

ASARCON®

CONTINUOUS-CAST BRONZE CASTINGS

Before you design or produce a copper base alloy part, investigate the economy and efficiency of Asarco continuous casting. You can order the alloy and shape you need, in the exact lengths you need. Continuous Cast Asarcon Bronze alloys meet SAE, ASTM, and government specifications—but they are superior to the same alloys cast other ways, in hardness, yield, tensile and impact strength. In fact, you may be able to substitute an Asarcon Bronze for an aluminum or manganese bronze. Write for complete data to Continuous-Cast Department, American Smelting and Refining Company, Barber, N. J. or Whiting, Indiana.

Immediately available from stock: **ASARCON 773 BEARING BRONZE** (SAE 660)—260 sizes of rods and tubes. Complete range of sizes from ½" to 9" diameters. Immediately available from stock in 105" lengths. Special shapes produced to order.

ASARCO

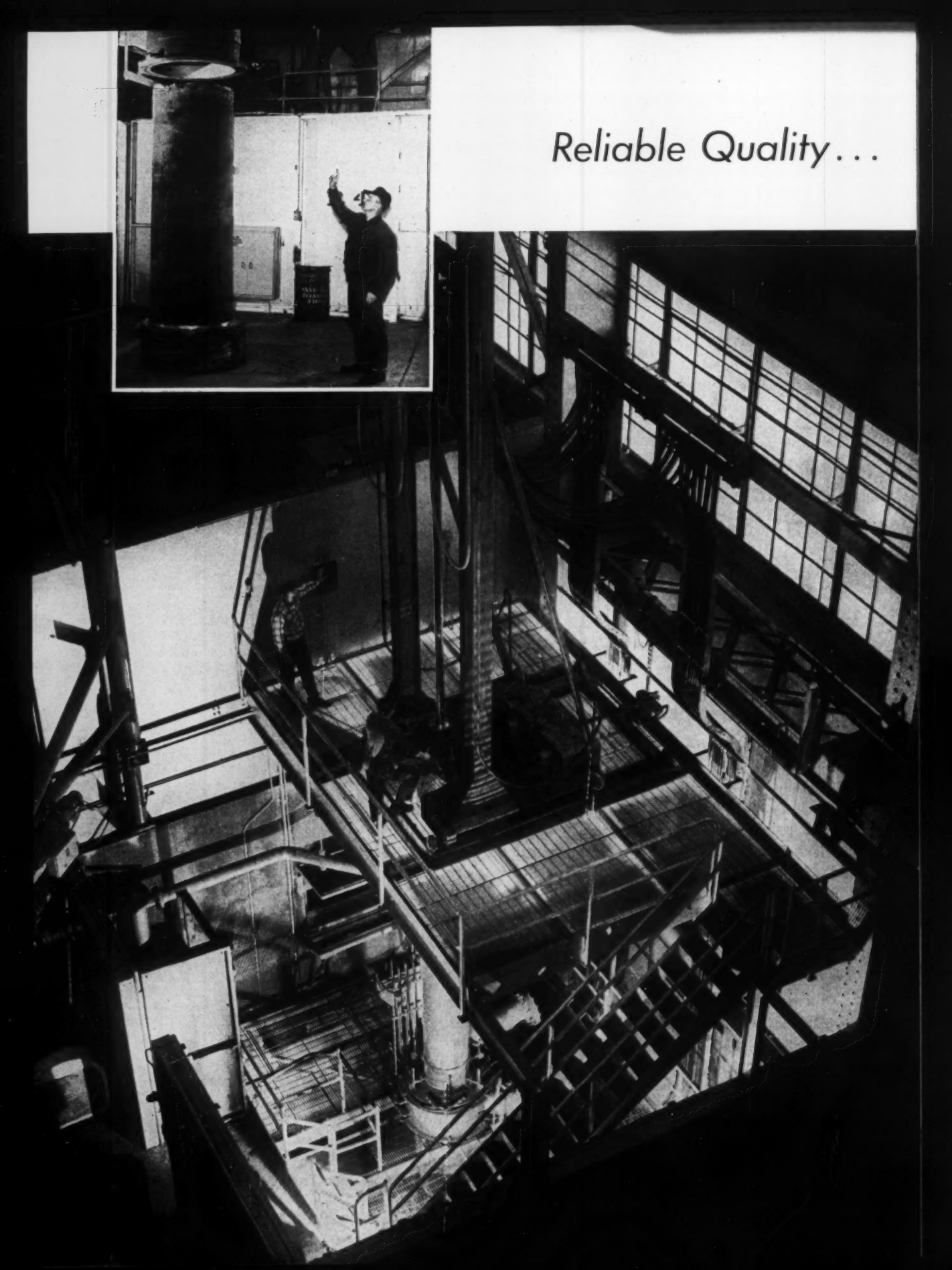
AMERICAN SMELTING AND REFINING COMPANY

Note minimum clean-up necessary between casting of this 6-tooth pump impeller and finished part. (Illustrated parts are 4" in diameter.)

CONTINUOUS CAST DEPARTMENT

West Coast Distributor: Kingwell Bros., Ltd., 457 Minna Street, San Francisco, Calif. In Canada. Federated Metals Canada, Ltd., Toronto and Montréal. Distributors in many principal cities.

For more information, turn to Reader Service card, circle No. 486


Reliable Quality . . .

In Quantity... On Time...

REPUBLIC VACUUM-MELTED METALS

Now produced in up to 20,000-pound heats!

For applications where *reliability* is of major importance, Republic offers *vacuum-melted* metals in ingots, billets, sheets, bar, strip, and wire.

The most extensive facilities ever assembled permit rapid delivery of vacuum-melted metals in quantity and in a wider range of sizes and conditions than ever before possible. Republic is producing vacuum-melted ingots weighing from 4,000 to 20,000 pounds in 18- to 32-inch diameters. Metals available include: super alloy steels, constructional alloy steels, high strength alloy steels, bearing steels, special carbon steels, stainless steels, and titanium.

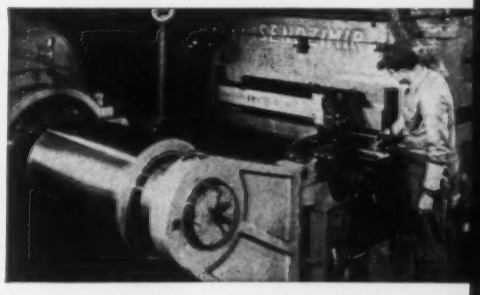
Republic uses the consumable electrode vacuum-melting process. Metals thus produced offer higher mechanical properties—ductility, tensile strength, and fatigue life. Non-metallic inclusions are reduced in number and size. Testing, certification, job setup, and production costs are reduced.

Our metallurgists and engineers are available to help you select, apply, and process the vacuum-melted metal best suited to your requirements. For complete information, contact your nearest Republic sales office today or return the coupon.

Super Alloy Steels • Constructional Alloy Steels • High Strength Alloy Steels • Bearing Steels • Stainless Steels • Titanium • Special Carbon Steels.

BILLETS—Republic's 3000-ton forging press converts vacuum-melted metals to large billets that are ideal for forged parts manufacture. Segregations associated with dendrite freezing are greatly reduced by the consumable electrode process and further alleviated by the greater hot work reduction ratios permitted by large ingots.

BARS—Vacuum-melted metals are converted into close-tolerance squares, rounds, hexes, and many other shapes on Republic bar mills. Virtually any size can be produced—from ¼″ to 10″ rounds and equivalent footweight sections. These bars offer improved ductility, tensile strength, fatigue life, and resistance to scaling.



SHEETS—Vacuum-melted stainless, titanium, and super alloy steels are converted to light gage sheet and strip on Republic's Sendzimir mills. Large coils up to 48″ (36″ maximum on titanium) wide are produced to close tolerances with excellent finishes and strength-to-weight ratios. Sheets up to 72″ wide can be produced on hand mills.

REPUBLIC STEEL

REPUBLIC STEEL

WHERE STEELS ARE MADE

TO MEET THE CHALLENGE OF ACCELERATION

REPUBLIC STEEL CORPORATION
DEPT. ME-9240
1441 REPUBLIC BUILDING • CLEVELAND 1, OHIO

☐ Please send more information on Republic Vacuum-Melted Metals
☐ Have a metallurgist call

Name_____ Title_____

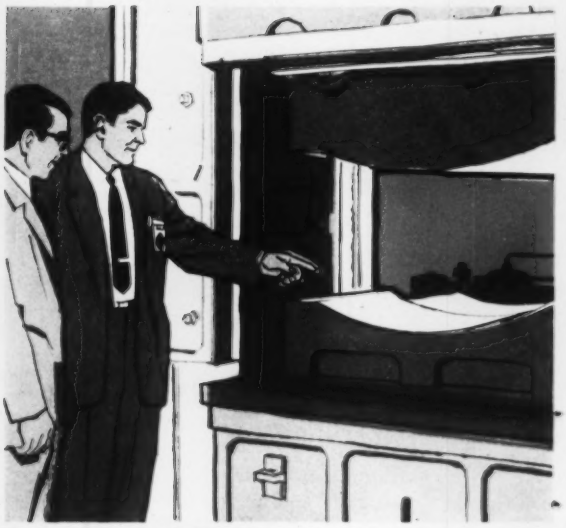
Company_____

Address_____

City_____ Zone____ State_____

For more information, turn to Reader Service card, circle No. 447

ELECTRONIC COMPONENTS—Outstanding electrical properties, dimensional stability, and temperature resistance are some of the reasons why Epon resins are preferred for potting, sealing, encapsulating, and laminating. Airtight bonds are formed to protect delicate electronic components. In addition, weight savings up to 50% are possible with these strong, light plastics.



TOOLING APPLICATIONS—Strong, high-quality forming tools and rugged, lightweight checking and assembly fixtures made from Epon resins can help reduce tooling costs, particularly for short production runs. Along with high strength and impact resistance, these modern plastics possess excellent dimensional stability for fabrication to close tolerances—reducing finishing expense.

SHELL is your source for

EPON® RESINS

...a complete line of epoxy polymers

When you make Shell your source

for epoxy resins, you can be sure of both prompt delivery and products that meet the highest standards set by industry. You can order Shell Epon resins from conveniently located storage facilities in quantities from drums to 30,000-pound lots.

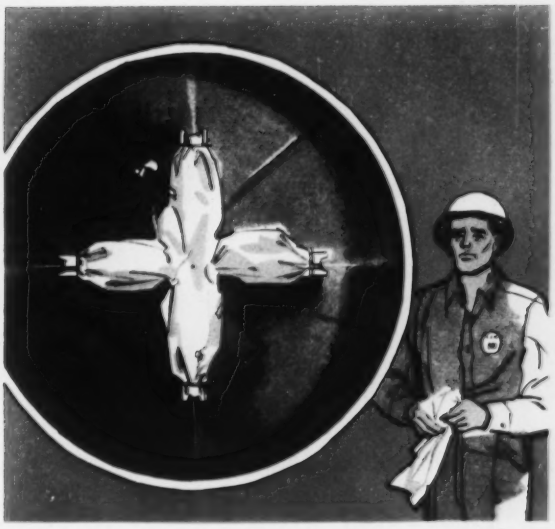
Epon Resin Solutions—

Epon 834, 836, 1001, and 1007 are also available in solution form.

Technical Assistance—Shell's technically trained personnel are available to assist you in making the best possible use of Epon resins.

Complete information on Shell Epon resins, which can help you in making your products better and less costly, is available upon request. Write today!

ADHESIVES—Instant assembly is possible with solvent-free adhesives based on Epon resins. They form strong bonds which, in special formulations, retain their strength at temperatures up to 500°F. They often replace welds or rivets and find considerable use in the manufacture of honeycomb panels, structural joints, radar antennas, and jet fuel tanks for the aircraft industry.



COATINGS—Epon resin-based coatings have become synonymous with durability. The outstanding resistance to wear, corrosion, chemical attack, heat, and humidity of these modern paints has been field-tested and proved for over ten years. They are used in automotive primers, specialized aircraft coatings, container liners, appliance finishes, marine paints, industrial maintenance coatings, and pipe and tank lining materials.

SALES SPECIFICATIONS

Epon resin type	812	815	820	828	834	836	1001	1002	1004	1007	1009
Melting point, °C[1]	liq.	liq.	liq.	liq.	liq.	40-45	65-75	75-85	95-105	125-135	145-155
Color (Gardner) max.[2]	3	5	8	5	5	5	4	4	4	5	5
Viscosity[2], 25°C Gardner-Holdt Poises	C-F 0.9-1.5	— 5-7	— 40-100	— 100-160	O-V 4.1-9.7	A_1-B 0.3-0.7	D-G 1.0-1.7	G-K 2.1-2.9	Q-U 4.6-6.6	Y-Z_1 18-28	Z_2-Z_5 38-100
Epoxide equivalent[3]	140-160	175-195	180-195	180-195	230-280	280-350	425-550	550-700	875-1025	2000-2500	2500-4000

TYPICAL PROPERTIES

Epon resin type	812	815	820	828	834	836	1001	1002	1004	1007	1009
Weight gal., lb.	10.2	9.5	9.7	9.7	9.7	9.9	9.9	9.6	9.6	9.6	9.9
Esterification value[4]	65	85	85	85	105	115	145	155	175	200	220

1. Durrans' Mercury Method
2. Epon 812, 815, 820 and 828 on undiluted resin; Epon 834 as a 70% solution in butyl Carbitol, all other types as 40% solutions in butyl Carbitol.
3. Grams of resin containing one gram-equivalent of epoxide.
4. Grams of resin required for complete reaction with one gram-mole of a monobasic organic acid, e.g., 60 g. of acetic acid.

SHELL CHEMICAL COMPANY

PLASTICS AND RESINS DIVISION

Central District
6054 West Touhy Avenue
Chicago 48, Illinois

East Central District
20575 Center Ridge Road
Cleveland 16, Ohio

Eastern District
42-76 Main Street
Flushing 55, New York

Western District
10642 Downey Avenue
Downey, California

IN CANADA: Chemical Division, Shell Oil Company of Canada, Limited, Toronto

SHELL

For more information, turn to Reader Service card, circle No. 521

Jet brake cup — LS-53
Synthetic lube diaphragm — LS-53
Diesel equipment seal — Viton
Drop-off tank seal — LS-53
Chemical pump liner — Viton
Natural gas valve diaphragm — Viton

For advanced fuel...hydraulic...lube systems,

New materials prove ideal in handling temperature extremes −350° F. to +750° F.

Working with two remarkably versatile elastomers, C/R Sirvene engineers are producing flexible molded parts for many vital fuel, lubricating, hydraulic and pneumatic systems. One, Viton-A*, can be compounded to produce parts that function dependably at 600° F., and for short periods up to 750° F. The other important feature of Viton compounds is their excellent resistance to corrosive chemicals, chlorinated solvents as well as both synthetic and petroleum base fuels and lubes. At the other extreme, C/R compounded Silastic LS-53** parts are providing low temperature operation down to -80° F. They also exhibit excellent resistance to synthetic and petroleum base fluids up to 350° F., and function well in propane up to 500° F. For temperatures as low as -350° F., C/R recommends Teflon* compounds.

C/R Sirvene engineers have an intimate knowledge of these elastomers. They also have perfected special techniques in processing which still further improve the physical properties of the molded parts. If your problem involves high or low temperatures, close tolerances, and compatibility in advanced design fuel, lubricant or hydraulic systems, get in touch with us at once. We have the skill and the facilities to help you.

* DuPont registered trademark
**Dow-Corning registered trademark

CHICAGO RAWHIDE MANUFACTURING COMPANY

SIRVENE DIVISION, 1227 ELSTON AVENUE • CHICAGO 22, ILLINOIS
Offices in 55 principal cities. See your telephone book.
In Canada: Chicago Rawhide Mfg. Co. of Canada, Ltd., Brantford, Ontario
Export Sales: Geon International Corp., Great Neck, New York
C/R PRODUCTS: C/R Shaft & End Face Seals • Sirvis-Conpor mechanical leather cups, packings, boots • C/R Non-metallic gears

C/R

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new

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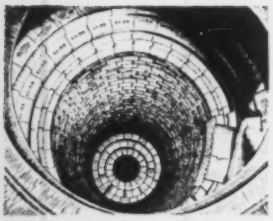
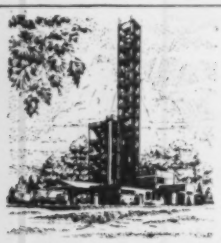
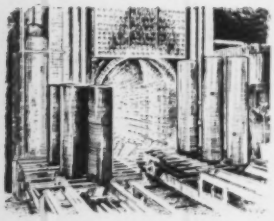


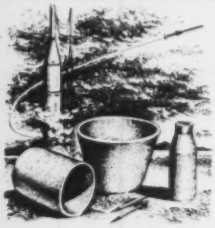
Pebble Heater Linings and Pebbles



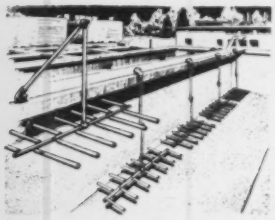
Chemical Reactor Linings



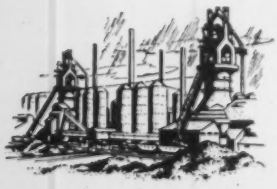
Muffle Plates and Kiln Shapes



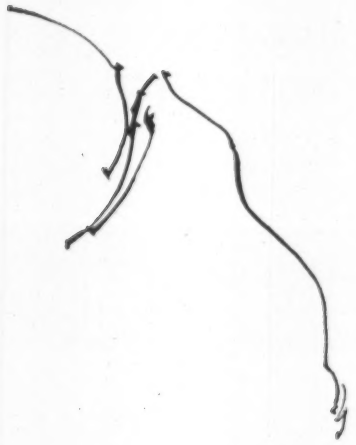
Missile and Rocket Ceramics



Porous Media for Sewage Systems



Wear Resistant Linings for sintering

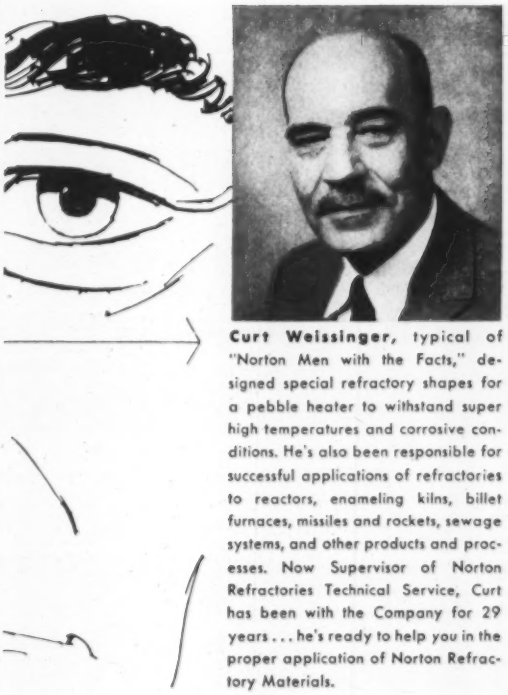


Working with today's imaginative design engineers, Norton Company's "Men with the Facts" are creating exciting new concepts in products and processes. Utilizing the wide variety of physical, chemical and electrical properties of Norton Refractory Materials, they help to solve design problems in products ranging from lightning arrestors to rockets . . . in processes as different as filtration and gas synthesis.

Norton's "Man with the Facts" knows where his company's product can best be applied. Perhaps the high thermal conductivity and high refractoriness of CRYSTOLON* silicon carbide are needed . . . or the excellent chemical stability and abrasion resistance of ALUNDUM* aluminum oxide.

to solve your design problems . . .

NORTON Refractories and the NORTON Man



Curt Weissinger, typical of "Norton Men with the Facts," designed special refractory shapes for a pebble heater to withstand super high temperatures and corrosive conditions. He's also been responsible for successful applications of refractories to reactors, enameling kilns, billet furnaces, missiles and rockets, sewage systems, and other products and processes. Now Supervisor of Norton Refractories Technical Service, Curt has been with the Company for 29 years . . . he's ready to help you in the proper application of Norton Refractory Materials.

Often MAGNORITE* magnesium oxide solves a problem with its high purity and excellent thermal conduction and high electrical resistance. Or, the immunity to oxidation and reduction of zirconium oxide, one of today's highest melting point oxides available in tonnage quantities, may be invaluable.

Find out how Norton Materials and Capabilities can improve *your* product, productive efficiency, and operating economy. Write NORTON COMPANY, Refractories Division, 348 New Bond Street, Worcester 6, Mass.

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Engineered . . . Rx . . . Prescribed

75 years of . . . Making better products
. . . to make your products better

NORTON PRODUCTS: Abrasives • Grinding Wheels • Machine Tools • Refractories • Electro-Chemicals — BEHR-MANNING DIVISION: Coated Abrasives • Sharpening Stones • Pressure-Sensitive T

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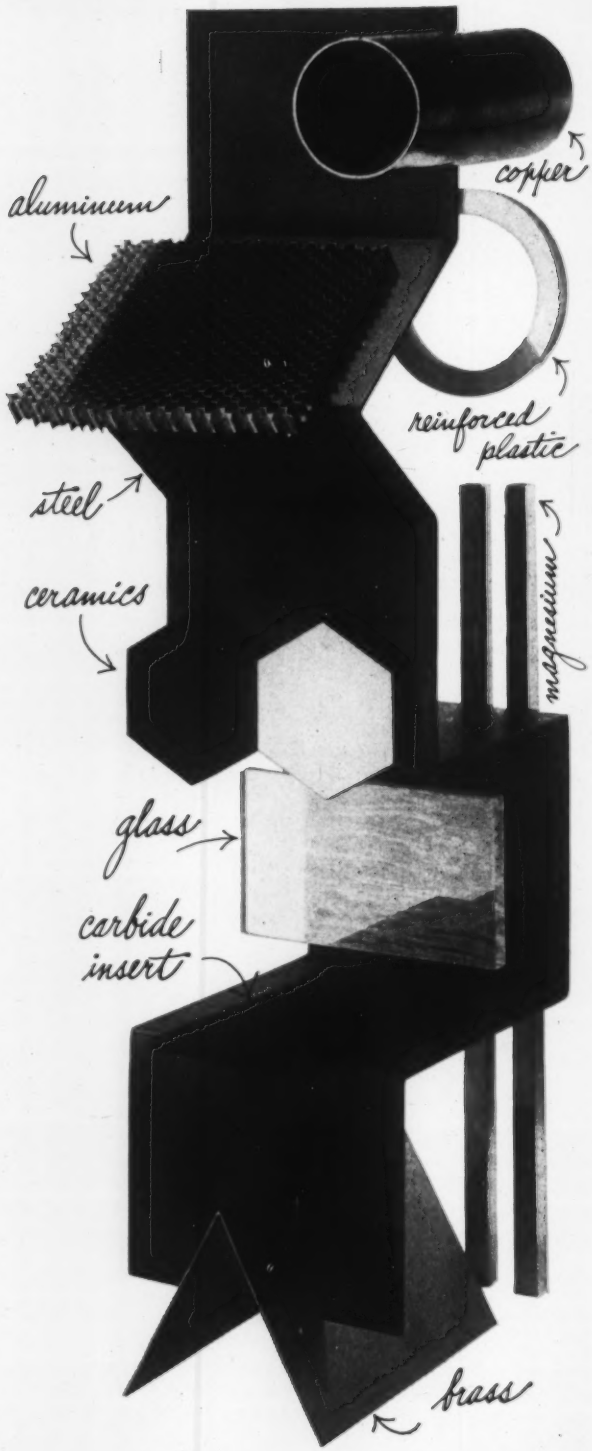
WHAT DO YOU WANT TO BOND TO WHAT?

Take a structural material—for instance, any of the materials shown to the right. Want to join it to itself or another material? Then chances are that SCOTCH-WELD® Brand Structural Adhesives are your best fabricating answer. This modern high strength method of joining materials permits improved design and production techniques . . . cuts costs . . . offers unique benefits.

For example: Smoother contours result when mechanical fasteners are eliminated. Fabricating complex shapes—often impossible or too expensive with ordinary fastenings—is made easy and economical with SCOTCH-WELD Adhesives. In fact, costly complex castings can often be replaced by two or more inexpensive simple castings bonded together with SCOTCH-WELD Adhesives. And lighter gage materials may be used where desired, since stress is spread over a wide area. Often, too, inspection and production steps can be eliminated. Another benefit—unusual combinations of materials which can be joined in no other way can be bonded perfectly with SCOTCH-WELD Adhesives.

Throughout the metalworking industry, bonding with SCOTCH-WELD Brand Structural Adhesives is improving quality, speeding production and cutting costs.

SCOTCH-WELD Adhesives may be the answer to your design and production problems . . . and improve your product at the same time. For full information write on your company letterhead, outlining area of interest, to: AC&S Division, 3M Company, Dept. SBHH-90, St. Paul 6, Minn. "SCOTCH-WELD" is a Reg. T.M. of 3M Co.



ADHESIVES, COATINGS AND SEALERS DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

. . . WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

For more information, turn to Reader Service card, circle No. 416

For more information, circle No. 358

working with

Du Pont Delrin®

one of Du Pont's versatile engineering materials

Air-brake couplings of Du Pont DELRIN® cost less...weigh less

By designing in a new material, Midland-Ross, Owosso, Michigan, produced a better coupling, costing less. To make these rugged couplings, which are used on the air-brake systems of truck trailers, it took a material as durable as new Du Pont DELRIN acetal resin. For example, Midland-Ross's tests require no leakage at 150 psi internal pressure, no creep in the locking ramps under 500-lb. load for 24 hours at 200°F, and operability after 5,000 breakaways. DELRIN easily passed these and other tough tests.

DELRIN is lightweight and corrosion-resistant, its non-sparking qualities offer greater safety. The resilience and stiffness of DELRIN give strength, which allows the couplings to separate under excessive load before air hoses break. Because DELRIN can be readily molded with a ramp-type lock construction, troublesome lock ball jamming and spring breakage are eliminated.

Versatile Du Pont DELRIN has already been put to good use in hundreds of applications, including household items, telephone components, gear housings, plumbing fixtures, valve parts and clothing fitments. On the next page you will find some of the product improvements made possible by the use of Du Pont DELRIN.

DU PONT

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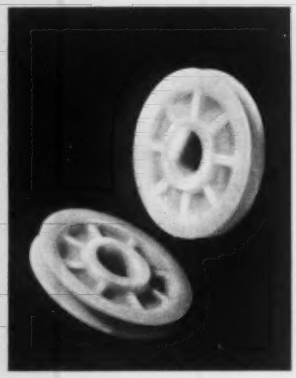
BETTER THINGS FOR BETTER LIVING ... THROUGH CHEMISTRY

working with

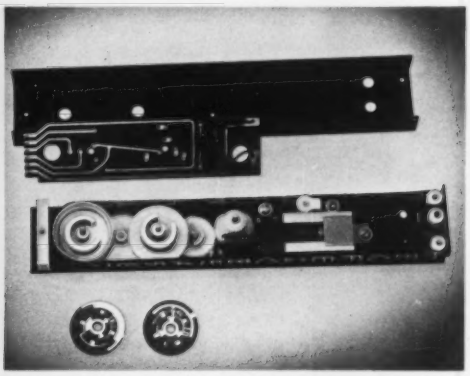
Du Pont Delrin®

one of Du Pont's versatile engineering materials

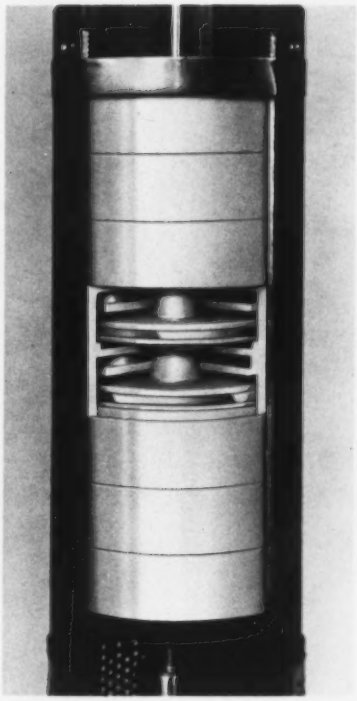
Typical end-uses show how Delrin® is doing so many jobs once reserved for metals



Long-wearing parking-brake cable pulleys of DELRIN are being used by a leading car manufacturer. The full radius groove in DELRIN provides natural mating, maximum contact area with the cable . . . eliminates the cable pinching caused by split-type steel pulleys. Pulleys have been tested under severe long-term conditions of high load and temperatures.



In their Post-Rite® data indicator, the General Railway Signal Co., Rochester, N.Y., uses nine parts of DELRIN, molded by Control Molding Corp. These gears, cams and rollers function as a gear train that guides a printed tape to a view port upon electrical impulse. These indicators must operate without lubrication at high temperatures with minimum maintenance. Only DELRIN could provide the dimensional stability, light weight, low-friction operation required in long-term use.



In an eight-stage submersible pump (two stages shown) precision-molded parts of DELRIN replace brass components . . . making possible improved performance, increased efficiency and a substantial cost saving. The Flint and Walling Mfg. Co., Kendallville, Ind., reports that DELRIN has given superior performance over brass in abrasion resistance and corrosion resistance and the prevention of mineral build-up . . . permits "top pump performance at bottom dollar prices."

Consider the strength, stiffness, dimensional stability, resilience and abrasion resistance of DELRIN acetal resins. These properties are retained even under exposure to wide variations in temperature, humidity, solvents and stress. Already hundreds of designs taking advantage of these properties and of the cost savings made possible by rapid injection molding have been specified or put into commercial production. We suggest that you investigate how DELRIN can be profitably used in the products you make and the products you use. Commercial processors and our own staff of technologists are ready to assist you.

POLYCHEMICALS DEPARTMENT

DU PONT

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BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

E. I. du Pont de Nemours & Co. (Inc.), Dept. A-1
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I am interested in evaluating DELRIN for the following use:

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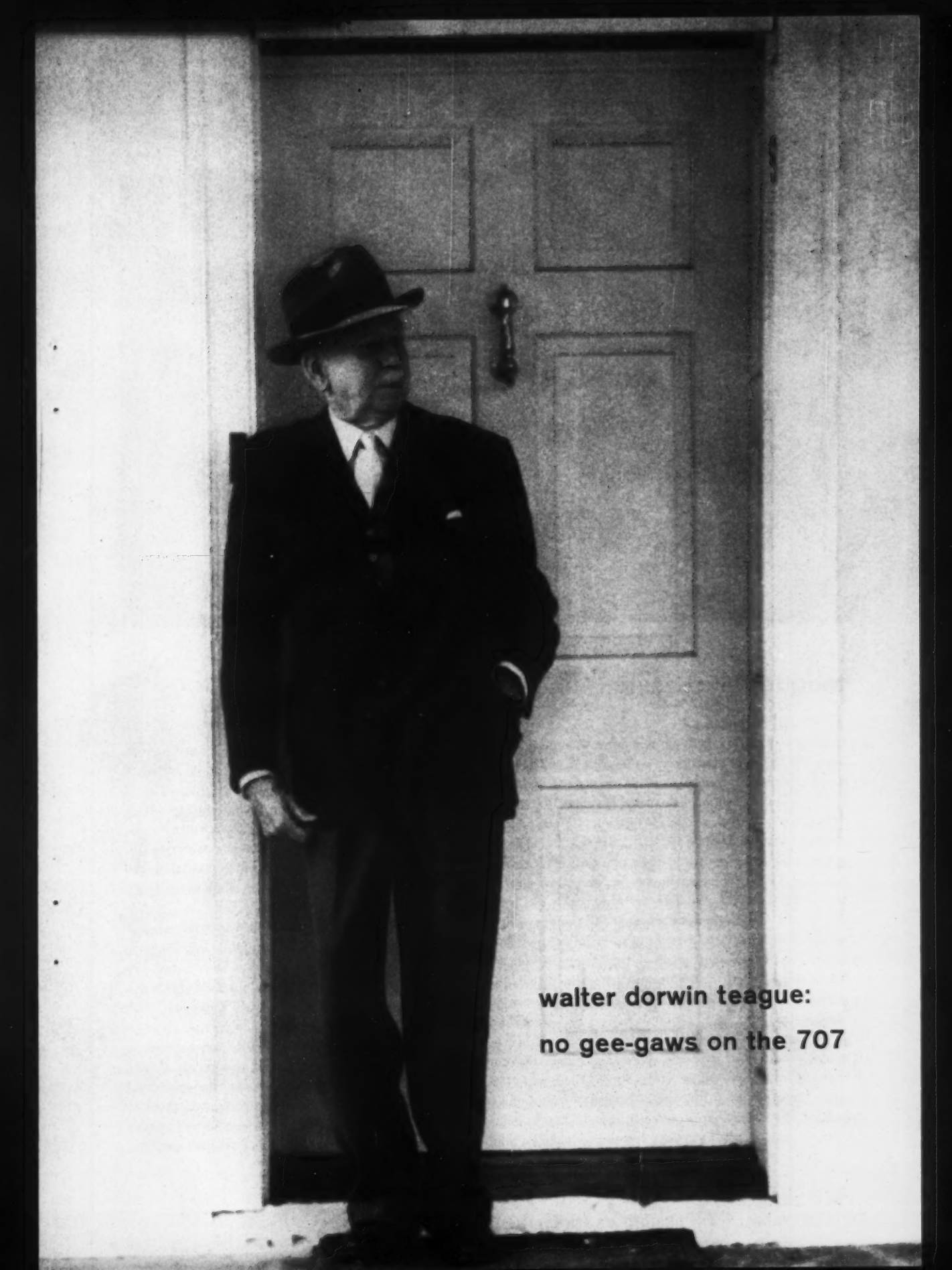
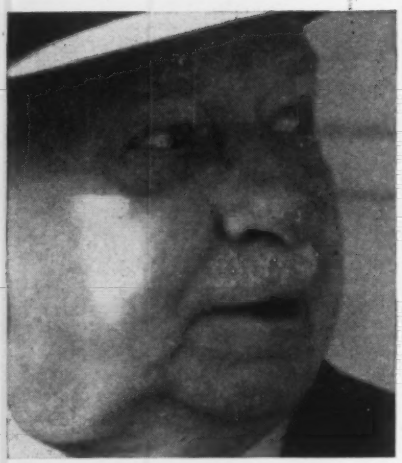
DELRIN® *acetal resins*

Alathon® · Zytel® · Lucite®



walter dorwin teague:
no gee-gaws on the 707



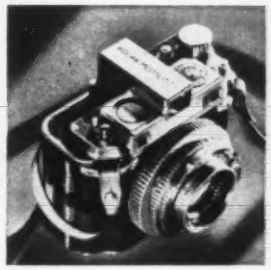
teague talks design

In 1942 a man named Walter Dorwin Teague published "You Can't Ignore Murder," a mystery novel. It is probably the only attempt at bafflement in his long history, because Walter Teague has been making products speak clearly for themselves since the Twenties.

Teague has rightly been called the dean of industrial design. He began as an artist in 1908 designing advertising, books and magazine illustrations. If you're old enough to remember Locomobile and Pierce Arrow ads, Teague designed them. In 1927, Eastman Kodak asked him to redesign their cameras. He made a proposal to spend one week a month in their plant observing production problems and techniques, and *then* redesign the cameras. That simple principle of knowing how a product is made, of understanding all the complexities of the production line, is still a Teague trademark. And Eastman Kodak is still a Teague client.

In the thirty-plus years since that camera assignment, Teague has explored just about every nook and corner of the wonderful world of three dimensions. He designed the classic Marmon 16 automobile in 1930, with his son as collaborator; he was on the Design Board of the 1939 World's Fair. When World War II exploded, the Navy asked Teague to perform design work on their 16-inch guns in order to eliminate possibilities of explosions caused by loading malfunctions. Today he still works for the Bureau of Ordnance. He has 120 people in his organization, a branch in San Juan and task forces scattered across the United States

Teague has designed service stations, railway equipment, plane interiors, heating appliances, business machines and machine tools, offices and furniture, showrooms and department stores, even periodicals. One of the most impressive things he has done is the Boeing 707 jet interiors. Mr. Teague recalls: "Boeing was concerned about their ability to sell the 707 because they hadn't made civilian planes for years. We convinced them to build a full-size mockup of the interior. They gave us *carte blanche* with body engineers to collaborate, and they refused to look at it until it was finished. We made it complete to the tiniest detail. It cost half a million



dollars and helped in selling most of the huge fleet now in the air. Our staff is responsible for the final interiors of the planes purchased by eighteen or more airlines, and for the interiors of executive planes purchased by the United States Government."

Whether mammoth jet airliners or chairs, a product is designed to five principles that are the *modus operandi* of the Teague organization. "First of all, the redesigned product has to work better for our efforts," Teague says. "It should be more convenient to use, more humanized. It must make honest use of the material it's made of, and it's got to be capable of being efficiently manufactured at the proper price. We assiduously avoid gee-gaws or extraneous ornamentation that adds nothing but price to the product. Finally, the design must give the user an emotional pleasure or gratification each time it is used." Selection of the right material for the job is important to each of Teague's requirements. "We endorse no material over another," Teague says. "We first look for the material that is best in keeping with the product's desired personality. Strength and durability are highly important in material selection. Then we make sure our client's tooling can handle the material we have in mind. Above all, it takes the right material to sell the product to the consumer."

Teague has used practically all materials known to man and it is no accident that a great many of his designs use steel in one way or another. "The wonderful thing about steel is its versatility," says Teague. "Its many alloys, old and new, give it adaptability that other materials don't have. Its strength, both in tension and compression, qualifies it for literally thousands of uses. And stainless steel is another reason why steel is a modern metal because it gives so many designs their contemporary look."

The moral is this: steel is an ageless metal, as much at home in the Boeing 707 and today's elegant tableware as it was in medieval days. Its enduring modernity will always be recognized and used by designers like Walter Dorwin Teague.

USS TRADEMARK **United States Steel**

designing with stainless steel

The ideal design has been described as one in which the properties of the material are fully utilized in the finished product. This ideal is difficult to achieve, and no group of materials comes as close to permitting this ideal as stainless steel.

To put it differently, no other material combines so many outstanding properties as the stainless steels. Stainless steels have high tensile strength. All are hardened and made even stronger by cold working. As a family they offer superb resistance to the corrosive effects of an enormous variety of reagents. They have unusual resistance to high temperature oxidation, and are distinguished by relatively low heat conductivity. And on top of their remarkable physical properties, stainless steel's lustrous appearance and sales appeal scarely need mention.

There are over 30 types of stainless steel today.

The history of stainless steel's use is marked by designers who turned a healthy profit with a quality material but mainly with sound ideas. They're the men who used stainless for its strength and sales appeal in toaster covers, its appearance and machinability in wrist watches, its structural properties and cleanability for truck trailer parts. Stainless steel cuts weight and adds years to the life of architectural panels; its corrosion resistance and smooth, pocket-free surface have made it the standard of the dairy industry. There are literally thousands of applications of stainless steel in which designers have utilized one, two or more of the remarkable properties of stainless steel.

By reflecting the color of its surroundings, stainless steel contributes to harmonious design.

Types 302, 410 and 430 make up 75% of stainless steel's uses.

Successful designers don't substitute stainless steel sections for sections of other materials. They design to stainless' unique properties.

Good design is honest design, whether it uses stainless steel or other materials. Yet the fact remains that there is no other commercial material quite as versatile as stainless steel. The applications shown on these pages are just a few of the hundreds of uses to which stainless is put every day. To learn more about stainless steel and its design properties, call our nearest sales office or write United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

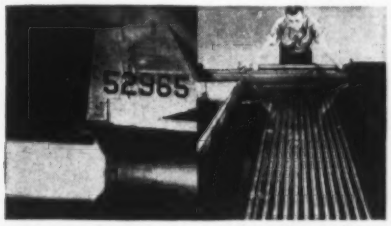
Good design doesn't stop with function and sales appeal. It must also be capable of economical manufacture. As a comprehensive guide, send for the free book described at the right.

Stainless steels represent but a few of the thousands of grades of steel in existence today. United States Steel makes a complete line of stainless steels as well as alloy, high strength and carbon steels. Bring your design problems to us.

USS is a registered trademark

USS United States Steel

No Material comes close to stainless steel's versatility. By way of illustration, here are a few "opposites" that prove our point.

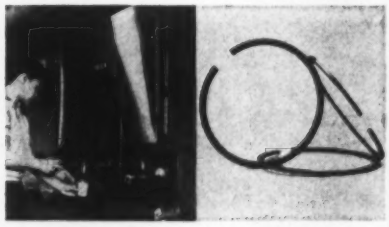


HOT. Temperatures in a jet afterburner reach 1400°F.

COLD. Stainless heat exchanger operates at temperatures as low as —443°F.

WET. Combination of moisture and coal would corrode nearly anything but stainless.

DRY. Rotary dryer is used to dry pharmaceutical ingredients.

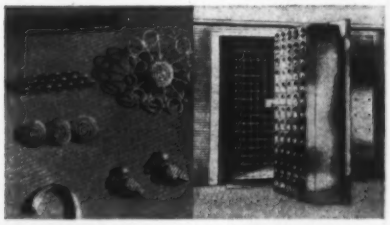


CLEAN. Milk dispensers of stainless steel prevent contamination.

DIRTY. Stainless piston rings resist high temperature corrosion.

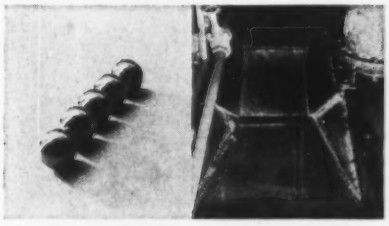
INSIDE. Chemical tanker needs simple wash-out for cleaning.

OUTSIDE. Stainless automobile trim stays bright and good-looking.



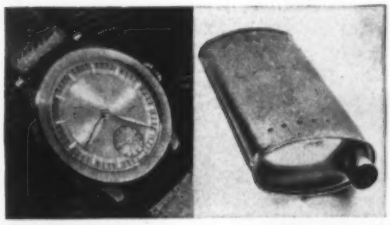
LIGHT. Stainless steel jewelry has a light, graceful appearance.

HEAVY. Strength and hardness of stainless combine to make safe doors safe.



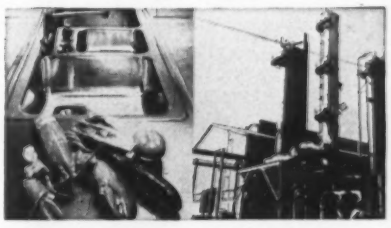
ROLL. Stainless ball bearings take a lot of punishment.

SLIDE. Abrasion resistance of stainless steel makes chutes last longer.



FORM. Stainless steel wrist watch keeps time and beauty.

FUNCTION. Stainless steel muffler defies heat with silence.



WATER. Stainless sinks stay bright and beautiful.

FIRE. Stainless steel shingles inside cat crackers are red hot.

This mark tells you a product is made of modern, dependable Steel.

For more information, circle No. 537

Stainless steel's properties require close control over processing and in some cases, special fabricating techniques. Its cold working and joining characteristics are of special interest to the designer and will often influence final design. For complete coverage of the subject, send for your free copy of our newly revised manual:

FABRICATION OF USS STAINLESS STEEL

Welding Austenitic Stainless Steels
Welding Ferritic Stainless Steels
Welding Martensitic Stainless Steel
Brazing
Joint Preparation
Jigs and Fixtures
Removal of Scale from Stainless Steels
Soldering
Joint Design
Lining of Vessels
Riveting
Machining
Cold Cutting
Flame Cutting
Cold Forming
Hot Forming
Annealing
Scale Removal
Passivation
Standard Mill Finishes
Surface Finishing
Grinding, Polishing and Buffing
Etching
Protection of Stainless Surfaces
Cleaning of Stainless Steels

United States Steel
Room 6143
525 William Penn Place
Pittsburgh 30, Pa.

Send me your new, just-off-the-press "Fabrication of USS Stainless Steel."

Name_____

Title_____

Company_____

Address_____

City_____

Zone____ State_____

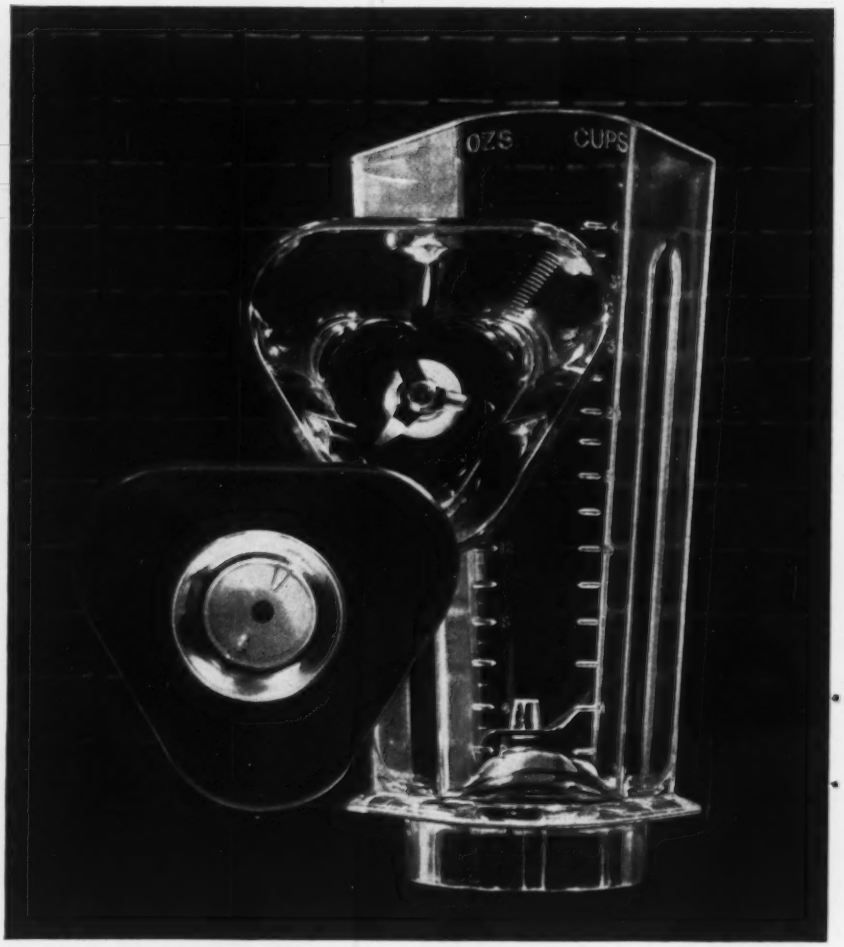
DOW

NEWS ABOUT PRODUCT DESIGN AND MATERIALS

From the technical development laboratories at Dow comes a steady stream of new applications for those versatile materials—the thermoplastics . . . new applications that accent beauty, function, production economy . . . new applications that stimulate ideas for your own designs and processes. The products described on these pages contain just a few of the Dow thermoplastics that are serving today's designers . . .

FUNCTIONAL DOW PLASTICS EXTEND PRODUCT DESIGN LIMITS

Within each broad category of Dow thermoplastics there are often several different formulations designed to pinpoint the functional requirements of designers and processors. Thus, you can select an individual Dow plastic material to extend the limits of your requirements for moldability, durability . . . lightness, inertness . . . beauty, clarity, or color . . .



One Dow thermoplastic—Tyril®—adds an extra measure of beauty, moldability and physical strength to the design of this modern built-in blender. Mixing, chopping, or liquefying in a matter of seconds, are just a few of its accomplishments.

To ensure its top performance under all forms of kitchen punishment, the designer specified clear Tyril for molding the blending jar. Tyril—a Dow copolymer of styrene and acrylonitrile—gives this appliance part toughness and high shock resistance to withstand the churning action of the high-rpm knife blades . . . its chemical resistance helps the jar stand up under the attacks of food acids and cooking ingredients . . . its temperature resistance protects against cracking or crazing over a wide temperature range—from mixing boiling liquids to crushing ice . . . and excellent moldability enables Tyril to reproduce the jar's complex shape and the finely detailed cup and ounce measuring marks. Washing presents no hazards, either. Detergents won't harm Tyril, nor will hot water, and it withstands normal abuse.

One of the problems designers have had to face when insulating a product is compensating for the added bulk and weight of thermal insulation. Today, designers have solved this problem with Pelaspan® – Dow expandable polystyrene in bead or pellet form. Foamed in place by the manufacturer, Pelaspan provides thermal insulation with negligible bulk or weight for this beverage cooler. (opposite page).

Pelaspan beads can be pre-foamed, expanded many times. When a molding or structural cavity is filled with them, and the beads are further expanded by steam, they tightly close up the interstices and make a molding of uniform density. The closed-cell structure created

has low thermal conductivity, low water absorption, low vapor transmission, and a high strength-to-weight ratio.

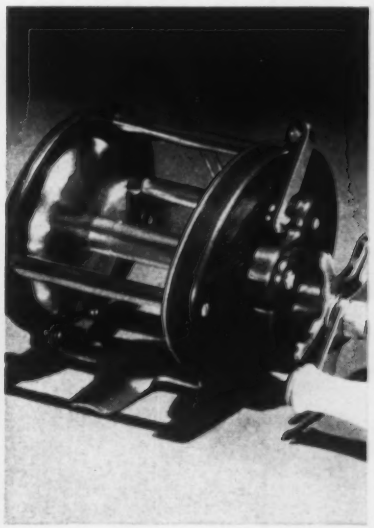
For the recreation market plastics help many products escape the limitations of older materials. A trio of Dow thermoplastics lend their specific talents to a fishing tackle box, a fishing reel, and an underwater mask and swim fin outfit . . .

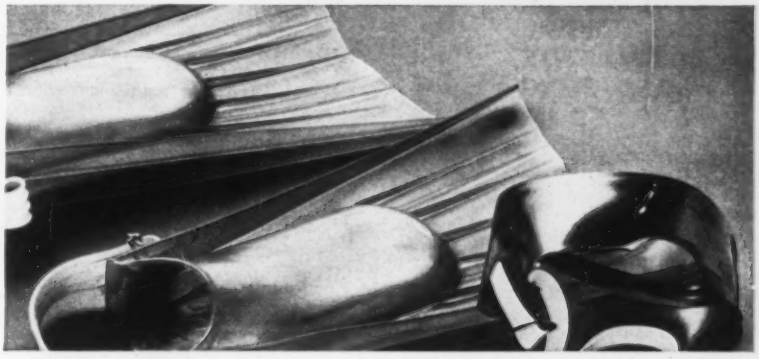
Built to last for a lifetime of fishing, the tackle box is molded of economical Styron® 480, a Dow super-high-impact plastic formulation with a green and white marbleized color effect. In addition to the inherent toughness to withstand a fisherman's hard knocks, Styron 480 has high heat resistance to endure the blazing hot sun without softening or warping. The excellent molding properties of Styron 480 – with emphasis on flow characteristics – allow the molder to produce a unique tongue and groove design along the edge. This makes the box watertight when closed–even allows it to float!

A colorful, economical solution to a design problem, this casting reel's end caps and knobs are molded of tough Styron 475. Styron 475 is a high impact formulation of the Dow family of polystyrene materials. Its impact strength is three to five times greater, and its elongation nine times greater, than general purpose polystyrene formulations. It resists salt water deterioration, and has good chemical resistance. Its fine molding characteristics reproduce sharp details faithfully.

Molded of an easy-to-process resin, an underwater face mask and swim fins of Dow PVC will last far longer than conventional materials. PVC permits the mask to fit snugly and comfortably across the face of the swimmer, with a sealing lip around the edges to prevent water seepage.

The PVC swim fins are lighter and stronger than conventional fins. What's more, the sun will not fade or rot PVC. Dow PVC is available in several different formulations. This wide selection permits a range of PVC compounds to fit almost any process or end use.





PROBLEMS, ANYONE? If a design or processing problem is puzzling you, chances are there's a formulation within the Dow Family of Thermoplastics that will solve it. If we can be of any assistance in helping you select the right formulation, or in production techniques, color styling, etc., please write us. THE DOW CHEMICAL COMPANY, Midland, Michigan, Plastics Merchandising Department 1720CD9.

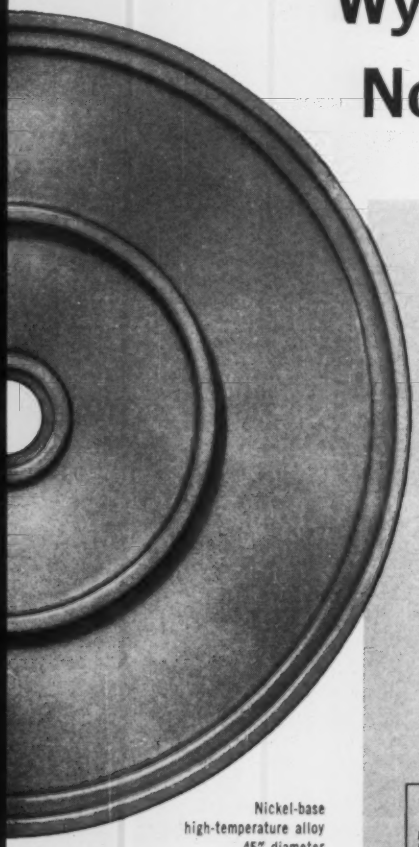
See "The Dow Hour of Great Mysteries" on TV.

THE DOW CHEMICAL COMPANY
Midland, Michigan

DOW

For more information, turn to Reader Service card, circle No. 355

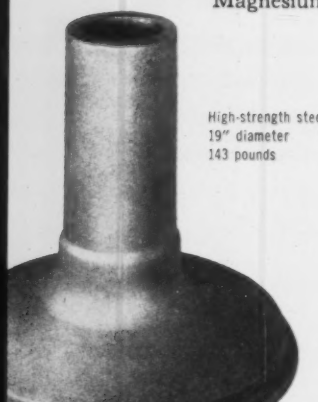
Wyman-Gordon makes a major
Now parts are being forged in



Nickel-base
high-temperature alloy
45" diameter
520 pounds

BROAD RANGE OF GAS TURBINE COMPONENTS ALSO BEING PRODUCED IN:

- Low-Alloy, High-Strength Steels
- Intermediate-Temperature Alloys
- Titanium and Refractory Metals
- Aluminum and Magnesium



High-strength steel
19" diameter
143 pounds

PHYSICAL PROPERTIES

TENSILE AND YIELD STRENGTHS

ALLOY*	TEST TEMPERATURE °F.	HEAT TREAT	GUARANTEED MINIMUM ULTIMATE TENSILE STRENGTH PSI	GUARANTEED MINIMUM 0.2% YIELD STRENGTH PSI	GUARANTEED MINIMUM ELONGATION %	TYPICAL VALUES ULTIMATE TENSILE STRENGTH PSI	TYPICAL VALUES 0.2% YIELD STRENGTH PSI	TYPICAL VALUES ELONGATION %
Waspaloy	RT	A	175,000	120,000	15.0	194,000	136,000	24.0
	1000	A	162,000	112,000	13.0	175,000	124,000	23.0
René 41	RT	B	180,000	132,000	12.0	200,000	150,000	15.0
	1400	B	135,000	115,000	13.0	145,000	125,000	18.0
Astroloy	RT	C	190,000	138,000	10.0	205,000	152,000	12.0
	1400	C	150,000	122,000	12.0	160,000	132,000	15.0
U-500	RT	D	175,000	120,000	10.0	195,000	135,000	12.0
	1400	D	125,000	105,000	12.0	140,000	120,000	15.0
M-252	RT	B	170,000	115,000	15.0	185,000	125,000	20.0
	1000	B	160,000	105,000	15.0	165,000	115,000	22.0

STRESS RUPTURE

ALLOY*	TEMPERATURE STRESS	GUARANTEED MINIMUM	TYPICAL VALUES
Waspaloy	1350°F.—70,000 psi	70 hours—6% Elongation	130 hours—16% Elongation
René 41	1350°F.—85,000 psi	30 hours—8% Elongation	60 hours—15% Elongation
Astroloy	1800°F.—20,000 psi	20 hours—7% Elongation	35 hours—12% Elongation
Udimet 500	1650°F.—25,000 psi	30 hours—6% Elongation	55 hours—12% Elongation
M-252	1500°F.—40,000 psi	30 hours—8% Elongation	55 hours—16% Elongation

NOTE: The guaranteed minimums are based upon radial and tangential test locations.

COMPOSITION AND HEAT TREATMENT

CHEMISTRY

ALLOY*	ELEMENTS C	Cr	Mo	Co	Ti	Al	B	Ni
Waspaloy	.08	19.0	4.3	13.5	3.0	1.4	.004	Balance
René 41	.08	19.0	10.0	11.0	3.1	1.6	.004	Balance
Astroloy	.05	15.0	5.0	15.0	3.5	4.3	.030	Balance
Udimet 500	.07	18.5	5.0	18.3	3.0	3.0	.003	Balance
M-252	.15	20.0	10.0	10.0	3.0	1.3	.002	Balance

HEAT TREATMENT

A.	1850°F.—4 hours—OQ; 1550°F.—2 hours—AC; 1400°F.—16 hours—AC
B.	1950°F.—4 hours—AC; 1400°F.—16 hours—AC
C.	2100°F.—½ hour—AC; 1400°F.—16 hours—AC
D.	1975°F.—4 hours—AC; 1500°F.—24 hours—AC; 1400°F.—16 hours—AC

NOTE: Refer to appropriate heat treat code in Tensile & Yield Strength table.

*Waspaloy: Pratt & Whitney Aircraft Corp.; René 41, Astroloy and M-252: General Electric Company; Udimet 500: Metals Division, Kelsey-Hayes Company.

contribution to gas turbine progress . . . these new Superalloys with Guaranteed Minimum Properties

permits designing to higher operating stresses . . . increased efficiency . . . greater component reliability for every gas turbine application

Rapid progress in developing the gas turbine has materially extended application of this prime power source to areas other than aircraft. Significant contributions in forging techniques and metallurgical advancements by Wyman-Gordon have in part made this possible.

Now designers are free to explore new frontiers of turbine performance unhampered by former material limitations. The high temperature alloys shown here exhibit outstanding tensile and stress rupture strengths in elevated temperature environments. These alloys have been forged into discs, shafts, rings, blades and vanes on a production scale.

Wyman-Gordon offers these alloys to *guaranteed minimum properties* for such vital components. This is made possible by the broad experience in forging parts from all difficult-to-work materials, including a complete range of low-alloy, high-strength steels; intermediate-temperature alloys; light metals; titanium and the refractory materials.

Our metallurgists and forging engineers are prepared to counsel on turbine components . . . evaluating material requirements and forging of existing designs and development parts. For assistance or additional information on Superalloy forgings, write—Product Manager, Turbine Applications, Wyman-Gordon Company, Worcester, Massachusetts.

WASPALOY

RENÉ 41

ASTROLOY

UDIMET 500

M-252

MEETING DESIGNERS' NEEDS IN EVERY TURBINE APPLICATION

- Aircraft and Missile
- Nuclear Power and Propulsion
- Rail and Highway Transport
- Power Generation
- Air Supply and Pumping
- Pipeline Boosting
- Auxiliary Service
- Automotive
- Marine Propulsion
- Stationary Power

Titanium
15½" length

EST. 1883

FORGED

Titanium
24½" diameter
191 pounds

WYMAN-GORDON

FORGINGS

of Aluminum Magnesium Steel Titanium . . . and Beryllium Molybdenum Columbium and other uncommon materials

HARVEY ILLINOIS WORCESTER MASSACHUSETTS DETROIT MICHIGAN

RESEARCH DEVELOPMENT

Practically all of the advances in surface treatments for metals have come from the big, ingenious Parker research staff. This consultation is on a new treatment for hot dip galvanized.

An improved Parker product for use in laminating plastic to metal undergoes checks and tests in the development lab. Parker products are carried from test tube to production line by Development.

Here's why the are Parker's conversion

Start with the experience and knowledge of the field which has built the Parker line. Our restless search for new ways and better ways to protect metals and increase finish durability has been continuous for almost fifty years, and has produced practically every major advance in the science.

Add Parker's free engineering service. Our staff engineers have designed literally thousands of practical, money-saving surface treating installations. This no-charge service includes detailed drawings and specifications —complete data ready for you to turn over to equipment builders for bids.

FIELD SERVICE

The Parker field service representative, stationed near you, averages 14¾ years of experience in the conversion coating field.

For more information, turn to Reader Service card, circle No. 462

TESTING SERVICE LABS

A corner of the testing labs, with the photomicrograph camera in use. Facilities include salt spray and humidity test rooms, outdoor exposure fields, equipment for all accepted testing procedures.

Customer Service Labs take your materials, treat them in Parker's $\$1/4$-million production line equipment, test the results obtained. Photo shows stock scheduled for 125′-long strip Bonderite machine.

biggest bargains in the business *coatings for your products*

Consider the qualifications of the Parker man who lives nearby and serves you. Our technical representatives have an average of $14\frac{3}{4}$ years of experience, equipping them to work with you and help you. They're practical, service-minded men, who bring understanding, ingenuity and dedication to you and your plant.

Back in Detroit, there are some 45 men working for you. These are our research and development people, manning the largest research program in the surface treatment field. Their discoveries of new processes, improvements and refinements are tested, proven, and passed on to you for your profit.

A $\$1/4$-million investment on your behalf is the production line Customer Service Lab. It's organized as an extension of your research and development program. Here we take your materials and treat them on a production line basis to work out the proper processing procedure, set time cycles, solve a cleaning problem, prepare material for experimental manufacture in your plant. All without charge.

For the low cost of the Parker chemical alone, you get this complete package of service and satisfaction. *It's the biggest bargain in the business.*

Parker Rust Proof Company
2173 E. MILWAUKEE, DETROIT 11, MICHIGAN

BONDERITE corrosion resistant paint base • BONDERITE and BONDERLUBE aids in cold forming of metals • PARCO COMPOUND rust resistant • PARCO LUBRITE—wear resistant for friction surfaces • TROPICAL—heavy duty maintenance paints since 1883

*Bonderite, Bonderized, Bonderlube, Parco, Parco Lubrite—Reg. U.S. Pat. Off.

Since 1914—leader in the field

For more information, turn to Reader Service card, circle No. 435

A service for engineers who must solve problems in:

HEAT · CORROSION

Useful data on advanced materials to help solve

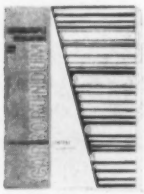
1 REFRACTORIES by Carborundum
A bi-monthly publication dealing with the properties and uses of specialized refractory materials.

5 "KT" SILICON CARBIDE
Technical Bulletin on Carborundum's new self-bonding SiC. Ideal for parts requiring high strength and resistance to high temperatures, corrosion and abrasion.

9 GLOBAR® RESISTORS
Technical Bulletins on characteristics of GLOBAR Thermistors, Varistors and fixed, non-inductive ceramic Resistors.

2 FIBERFRAX® CERAMIC FIBER
Bulletin includes detailed data on forms, properties and suggested applications of Carborundum's new, high temperature material.

6 BORON NITRIDE
Technical Bulletin covers this easily machined ceramic material having unique electrical and corrosion resistance properties up to 3000 F.



10 THERMOCOUPLE INSULATORS
Data includes characteristics, standard shapes and sizes of ceramic tubes and heads for thermocouple insulating applications.

3 ZIRCONIUM DATA FILE
Loose-leaf binder containing all data on properties, fabrication, availability and application of Zirconium metal and alloys.

7 "GRB SILICON CARBIDE
Technical Bulletin on SiC Bonded Graphite material with high thermal shock resistance and ability to withstand oxidation and erosion at high temperatures.

11 STUPALOX CERAMIC CUTTING TOOLS
Manual covering properties, design data, performance and applications of hot pressed alumina cutting tools for high-production machinery.

4 KOVAR® ALLOY
Brochure includes properties and application information on this iron-nickel-cobalt alloy for glass-to-metal and ceramic-to-metal seals and assemblies.

8 SILICON CARBIDE FOAM
Data Sheet on new, light-weight cellular silicon carbide. Offers corrosion resistance, high porosity and thermal insulation for use up to 4000 F.

12 FERROCARBO® DEOXIDIZER
(for Malleable Iron Castings)
Bulletin covers this deoxidizing material for production of malleable cast iron with superior casting and mechanical properties.

ABRASION

problems encountered in exotic environments

Advanced Materials . . . able to resist extremes of heat, corrosion and abrasion . . . are being developed at Carborundum to help solve many of industry's critical problems in product and process design.

Alert development and design engineering staffs in industry are discovering that the unique properties of these completely new materials offer solutions — often spectacular — in areas where conventional materials are inadequate.

To acquaint designers and engineers with the properties and potential applications of advanced materials, a broad selection of literature is available. Please use the coupon below to select from the representative literature pictured and described at left. For specific application help, write to *Research & Development Division, The Carborundum Company, Niagara Falls, N. Y.*

For the latest on advanced materials developments

write for free subscription to "Advanced Materials Technology," a quarterly publication devoted to advanced materials developments and applications. Write Dept. MDE, Carborundum, Niagara Falls, N. Y.

Where conventional materials fail . . . count on

CARBORUNDUM®

THE CARBORUNDUM COMPANY
Research and Development Div., Dept. MDE
Niagara Falls, N. Y.

Please send me the literature checked below:

- ☐ 1 Refractories by Carborundum
- ☐ 2 FIBERFRAX Ceramic Fibre
- ☐ 3 Zirconium Data File
- ☐ 4 Kovar Alloy
- ☐ 5 "KT" Silicon Carbide
- ☐ 6 Boron Nitride
- ☐ 7 "GRB" Silicon Carbide
- ☐ 8 Silicon Carbide Foam
- ☐ 9 GLOBAR Thermistors, Veristors and Resistors
- ☐ 10 Thermocouple Insulators
- ☐ 11 STUPALOX Ceramic Cutting Tools
- ☐ 12 FERROCARBO Deoxidizer
- ☐ Advanced Materials Technology House Organ

Name_____

Position_____

Company_____

Street_____

City_____ Zone_____ State_____

UP TO 40 TIMES LONGER WEAR

LINDE's FLAME-

—the 6,000-degree, supersonic process that "welds" tungsten carbide and other materials to working surfaces—giving them today's greatest resistance to abrasion, galling, erosion, fretting, corrosion, and high-temperature wear

LONGER service life . . . less down time . . . fewer rejects . . . reduced operating costs!

These are only a few of the important advantages that LINDE's Flame-Plating process builds into machines, parts, accessories, and products that depend on the stamina of metal surfaces for required performance. Exclusive Flame-Plating guns literally "blast" molten particles of tungsten carbide or aluminum oxide at specific areas—at 2,500 fps—depositing a hard, welded-on coating which can be precision-finished to the desired microinches rms.

Dimensional stability unchanged

While temperatures above 6,000°F. are reached within the oxy-acetylene detonation gun, the temperature of the work piece is maintained below 250°F. This eliminates warpage or distortion of even minute precision parts.

Depending on thickness of finish applied, or use of the wearing part, Flame-Plating has been known to multiply wear resistance more than 40 times.

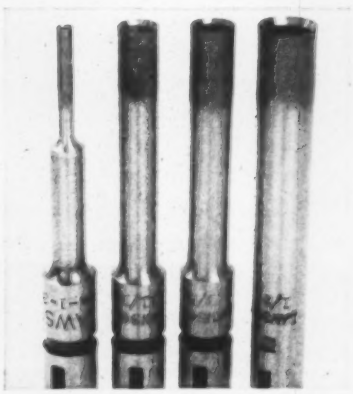
Hundreds of potential applications

Other properties include low coefficient of friction, porosity less than one per cent, and excellent corrosion resistance. Coatings show outstanding reliability under high temperature, heavy load, and lack of lubrication or cooling.

The list on the right-hand page (opposite) shows a few of the many current and possible applications for Flame-Plating. Perhaps the process could be used profitably in one or more of your operations. We suggest you indicate your possible applications on the coupon and mail today for more information.

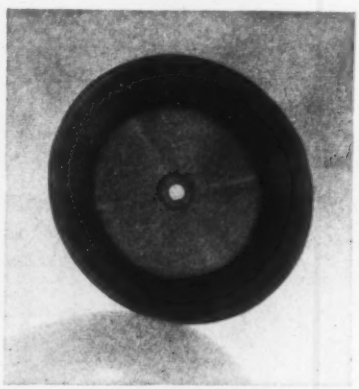
ROBESON CUTLERY

LINDE's Flame-Plating provides Robeson Cutlery Co., Inc., with a distinctive merchandising theme. The Robeson line of *"Flame Edge"* cutlery is featured as "The Greatest Development in 2000 years of Cutlery Making —a Cutting Edge of Tungsten Carbide."



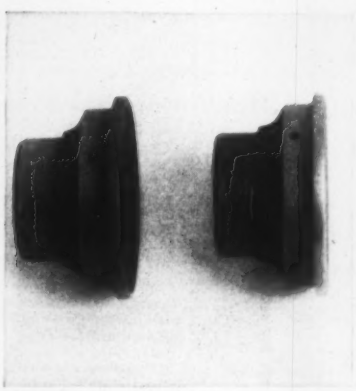
LAWSON PAPER DRILLS

Paper manufacturers report increases in drill life up to 20 times with Lawson Company Flame-Plated tips. Less "puckering" delivers better quality; fewer stops for sharpening bring savings which outweigh the extra cost of Flame-Plating many times over.



RUBBER SKIVING KNIVES

Before Flame-Plating, skiving knives used in the rubber industry had to be sharpened after every shift. Since adoption of Flame-Plating the service life of this tool has been increased 15 times. A sharp edge is always present, due to a *self-sharpening* effect.

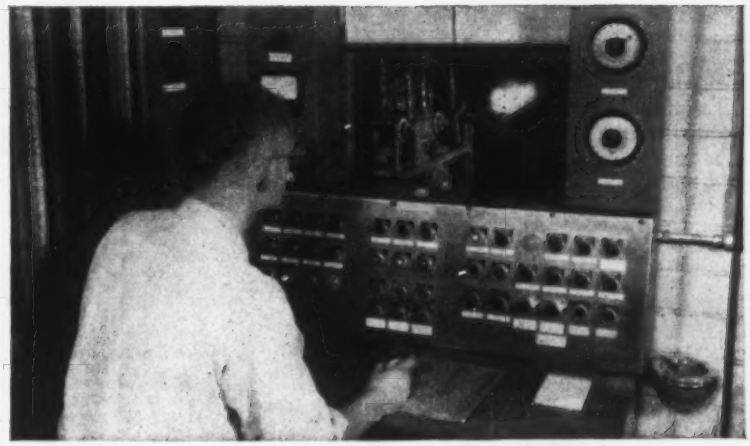


SEAMING CHUCKS

LINDE's Flame-Plating is an important time-and-money-saver for the abrasive-resistant, tolerance-stable seaming chucks used by major canners. Operating life is more than 4 times longer. Chucks, when worn, can be salvaged, replated, and returned to use.

for Metal Parts – Metal-Coated by

PLATING



THE "LINDE" FLAME-PLATING GUN—and how it works

In LINDE's revolutionary Flame-Plating process, precise quantities of oxygen, acetylene, and tungsten carbide powder—representing "powder and shot"—are fed into the gun by a special mechanism. The gun is aimed at the areas to be coated, then fired by remote control. Precision-controlled rapid-firing (4 per second) builds up the coating to the desired thickness. The as-coated smoothness of 125 microinches rms can be finished down to better than 1 microinch rms finish.

PHYSICAL DATA—FLAME-PLATED COATINGS

COATING DESIGNATION	LW-1	LW-1N	LW-5	LC-1A	LA-2
Approx. Composition by weight	Tungsten Carbide +6% to 8% Co	Tungsten Carbide +13% to 16% Co	25% WC +7% Ni + mixed W-Cr Carbides	85% Cr_3C_2 + 15% Ni-Cr	99% + Al_2O_3 (gamma)
Hardness Vicker's (VPN_{300})	1200 to 1450	1050 to 1150 VPN 70 to 71 R_c	1000 to 1200 VPN	850 VPN	1000 to 1200 VPN
Maximum temp. in oxidizing atmosphere	1000°F.	1000°F.	1400°F.	1800°F.	1200°F. to 1800°F.
Coefficient of thermal expansion	4.0 x 10^{-6}/°F. Avg. 70 to 1000°F.	4.7 x 10^{-6}/°F. Avg. 70 to 1000°F.	4.6 x 10^{-6}/°F. Avg. 70 to 1400°F.	6.4 x 10^{-6}/°F. Avg. 70 to 1800°F.	3.9 x 10^{-6}/°F. Avg. 70 to 1832°F.
Modulus of Rupture	67,000 psi	80,000 to 106,000 psi	40,000 psi	75,000 psi	22,000 psi
Modulus of Elasticity	44 x 10^6 psi	42 to 40 x 10^6 psi	17 x 10^6 psi	22 x 10^6 psi	16 x 10^6 psi
Porosity	0.5%	0.5 to 1.0%	0.5%	0.5%	1.0%
Specific Gravity	14.2	13.2	10.1	6.54	3.45
Specific Heat	0.048	0.056	0.070	0.127	0.196
Thermal Conductivity	5.3 at 500°F.	5.3 at 500°F.	3.8 at 500°F.	4.3 at 500°F.	0.86 at 500°F.
Main features	Extreme wear resistance	Excellent wear resistance + increased resist. to mechanical and thermal shock.	Excellent wear resist. to higher temps. Improved corrosion resist.	Good wear resist. at high temp. or in corrosive media. Resists flame impingement.	Excellent resist. to wear, chem. attack and high temperature deterioration.

TYPICAL FLAME-PLATING APPLICATIONS

BEARINGS – sleeve, roller, gas
BLADES – aircraft turbine; doctor blades for papermaking
BLOCKS – anvil
BUSHINGS – ball piston pump
CHUCKS – seaming
CUTLERY – household
CUTTING, INDUSTRIAL – rubber, plastic, skiving knives, foods, paper, slitter knives, chipper knives, discontinuous chip-abrasive materials
DIES, TOOLING – cold-forming; coring punches, core rods, sizing punches, capstans
DOGS – sewing machine feed; gripping dogs
DRILLS – paper, acoustical tile, twist
GAGES – plug, ring, air
GUIDES – wire, textile, machine
HYDRAULICS – pistons, liners, valve plates, wobble plates, metering valves, servo valves, slippers
MANDRELS – wire-forming
PARTS – sintered
PISTON RINGS
PLATES – valve, wear
SEALS – turbine engine, pump
SURGICAL – needle holders and shears
VALVES – aircraft

MI-9

Linde Company, Flame-Plating
270 Park Avenue
New York 17, New York

I am interested in Flame-Plating for the following application(s):

_____

_____

_____

NAME _____ TITLE _____

COMPANY _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____

LINDE COMPANY
Division of Union Carbide Corporation

UNION CARBIDE

LINDE and UNION CARBIDE are trade-marks of Union Carbide Corporation.

For more information, turn to Reader Service card, circle No. 497

ZINC COATED STEEL

Is The Proven Answer To These

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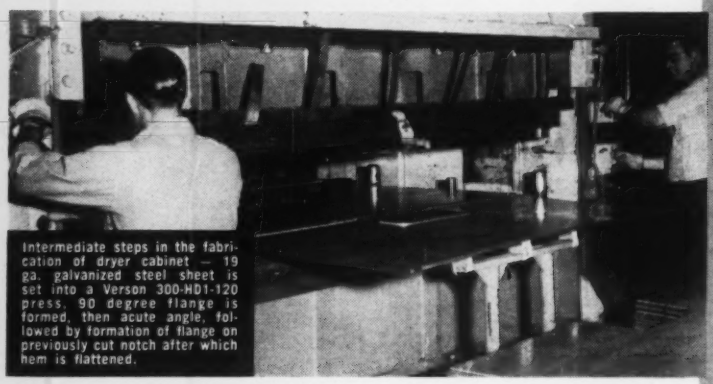

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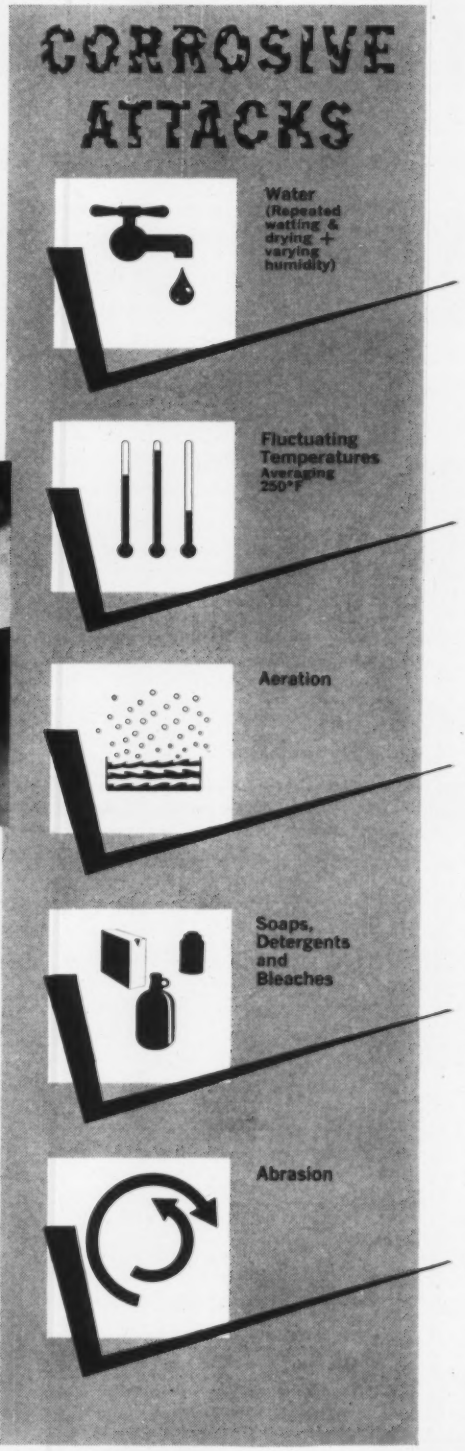

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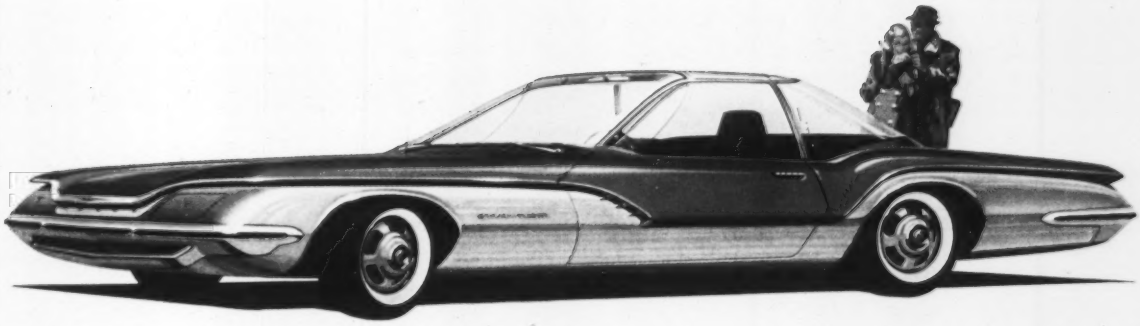

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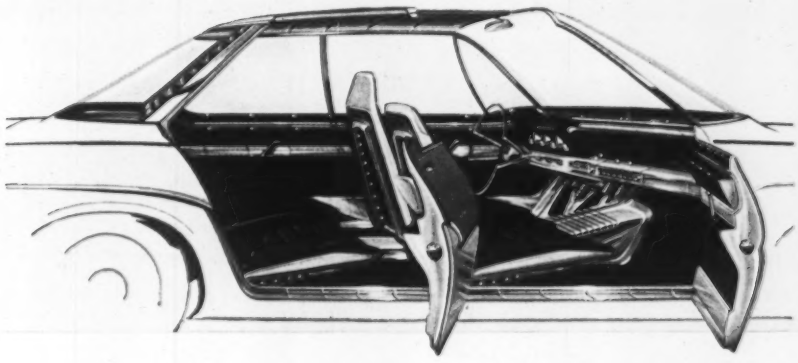

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Impressive cost savings can result when BEE CHEMICAL coatings are applied over neutral or non-pigmented calendered sheet or plastisols to achieve the range of special colors normally required in automotive or similar applications.

These coatings, while specially developed by BEE for the automotive industry, can provide the same cost-saving, quality performance results in other products: *e.g.*, appliances, business machines and sporting goods.

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DECORATING OF SHORT-RUN, SPECIAL COLOR MOLDINGS

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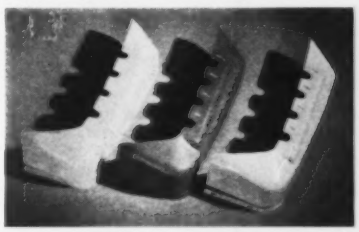
The painting of neutral-colored or reprocessed plastic results in an immediate savings on material costs as compared with small-quantity purchases of special color materials. The wide color variety (including Bronzeless Golds and pigmented metallics which are difficult to "mold in"), the production ease and color control possible with the BEE system make this a production tool worth investigating by large and small molders alike.

Significant additional advantages result from the BEE system: elimination of the costs of color changes in press down-time and press purging and material wasteage encountered in rejects when starting a press run on a new color; the cost of storage space necessary to warehouse a variety of special-color styrene powders; the possible waste of special-color materials purchased over actual job requirements for anticipated reject volume.

The BEE system has also found an ally in the designer torn between the high costs of achieving color variety and its desirability for maximum product appeal.

Send for more facts on the subject of painting vs. molding in color, complete with comparisons on material volume and application costs.



An actual case in point: The high-impact styrene TV end caps shown here for a 17" portable were molded and decorated by G. Felsenthal & Sons, Inc., Chicago. The part was previously injection molded in the special colors required. Succeeding orders for smaller runs in the special colors made painting of neutral-colored stock desireable from an economical standpoint. The neutral-colored end cap is shown at left, the grey and tan special colors at right. The molder reports a 20% material cost savings on this part by painting with Logo R-222 as compared with molding in color.

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An up-to-the-minute listing of BEE CHEMICAL COMPANY's line of metallizing, decorative, protective and functional coatings for spraying, dipping or flow coating; plastisol formulations and special purpose coatings are all detailed in BEE's COATINGS SELECTOR. Fill in coupon to get a copy.

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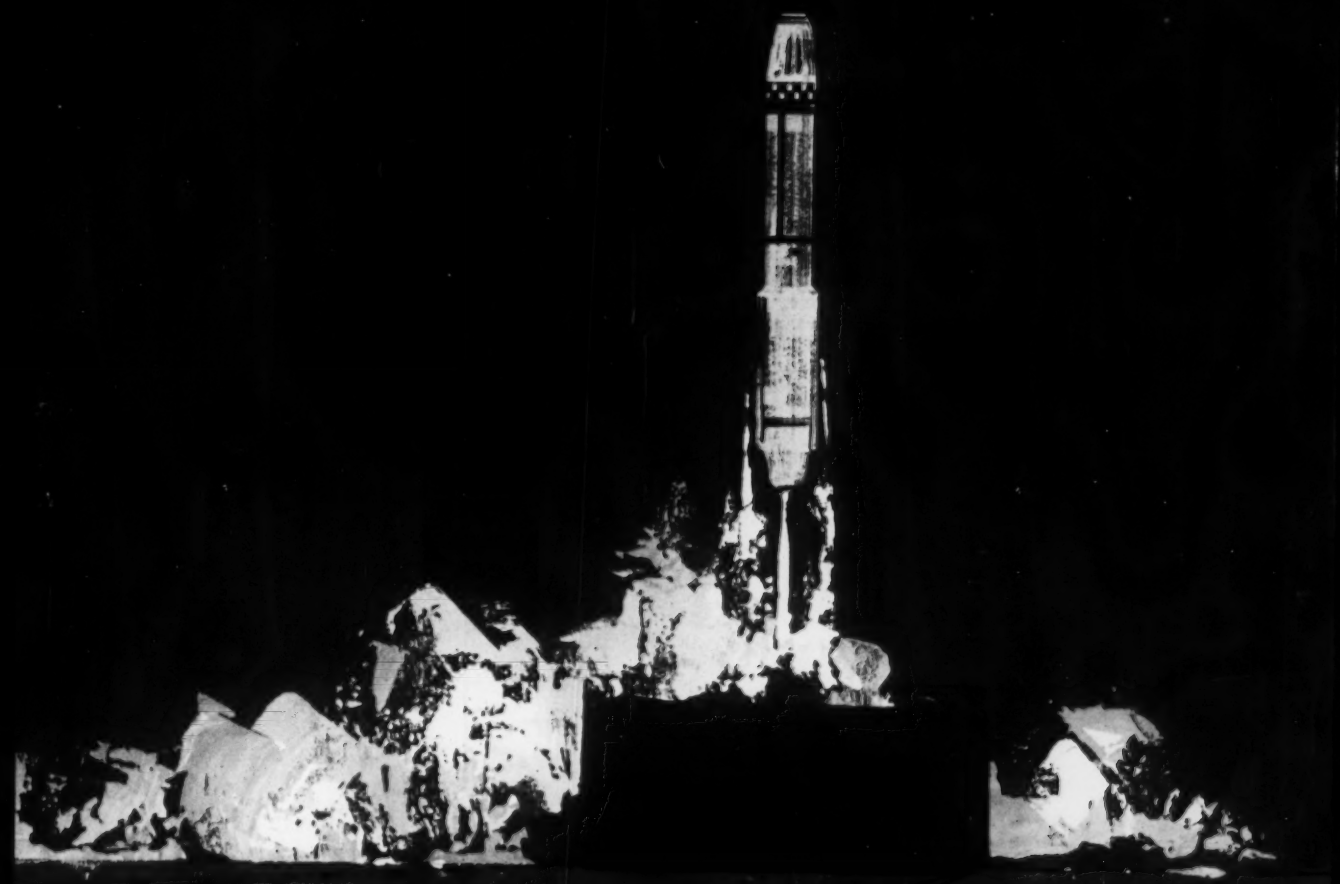
In the development of solid-fuel rocket cases, a leading manufacturer fabricated and experimented with welded steel and glass fibers, as well as many steel wire specimens, to find a fuel case material with the most favorable strength-to-weight ratio for fuel case applications.

EARLY DEVELOPMENT STAGES—At the outset of their testing program, the rocket manufacturer asked National-Standard to develop .004″ wire with 575,000 psi, the ultimate tensile strength required of steel wire to provide the strength-to-weight ratio needed. The wire was to be made into tapes of uniformly-stressed wires, coated with epoxy resin to separate the wires, and wound over collapsible mandrels to form the fuel case.

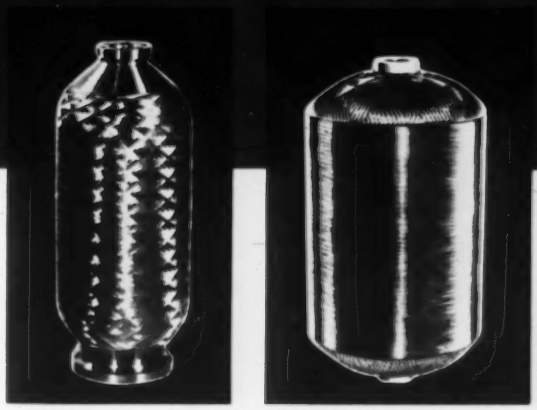
NATIONAL-STANDARD ENGINEERS produced .004″ high-carbon steel wire that met every specification, after intensive testing with many types of wire and finishes. Special wire developed by NS met rigid size tolerances, residual twist and controlled cast requirements.



ROCKET FUEL CASES

The end result of NS—customer cooperation was the ability to produce wire-wrapped rocket cases with very high hoop stress and lower cost than those being produced by other methods. And the fuel case manufacturer is able to provide maximum case-to-case reliability.

EXPERIENCED ENGINEERING HELP of this kind is available to you from National-Standard to meet special or unique high-quality wire applications. Write for additional information to National-Standard Company, Niles, Michigan.



WIRE-WRAPPED ROCKET CASES are wound over collapsible mandrels using a number of strands of very high strength, small diameter wire formed into tapes.

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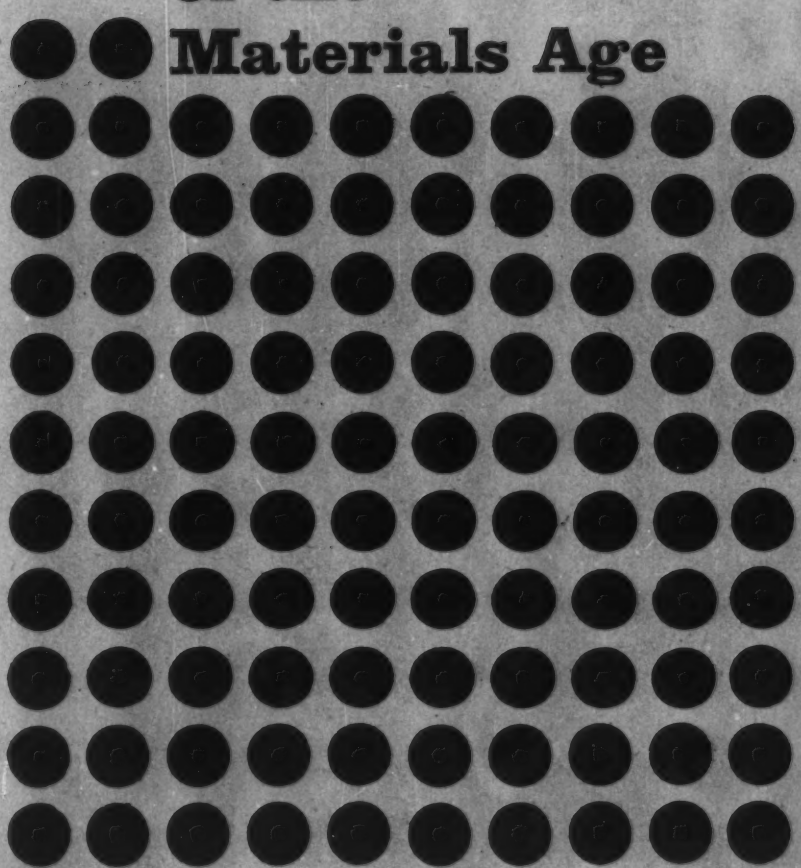
The Challenge of the Materials Age



Materials in Design Engineering | Special Report No. 175 | September, 1960

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Foreword

The Materials Age is here and will be with us for a long time to come. It is an age in which the materials available to man are limitless in number and diversity. It is an age in which the microscopic similarities of all materials are more significant than their macroscopic differences. It is an age in which most advanced mechanisms are critically dependent on materials. Yet it is an age in which new materials still to come promise almost unbelievable breakthroughs in the devices of automation, miniaturization, communication, space exploration, and the maximum utilization of energy. ■ The Materials Age is an age made by man. It is an age that calls for men capable of grasping and using the new science of materials, for men farseeing enough to break down the conventional barriers of the various engineering disciplines. It is an age that requires us to reappraise our ways of doing things. In education it has raised questions of how best to teach materials to engineers. In research and development it has raised questions of how to most efficiently plan and administer the vast government-sponsored programs. In industry it has raised questions of how best to organize to handle materials problems. In technical societies it has raised questions of scope, has stimulated reappraisals of programs, and has spawned entirely new societies. And in the information field it has created formidable problems in collecting, evaluating and disseminating data on materials. ■ The following special report examines the Materials Age — its genesis, its meaning, and its impact upon our existing institutions. Many thoughtful scientists, engineers and administrators have contributed ideas to this report. Perhaps it will offer a helpful perspective to many who, consciously or not, have been thrust into the Materials Age to stay.

This Is the Materials Age

Three of the eras in man's past history have been designated the Stone Age, the Bronze Age and the Iron Age. They were thus named because the civilization of each of them was dominated by and dependent on one material.

Now again, in this present century, materials have assumed a position of pre-eminence. They are perhaps the most important single factor upon which the advance of our technology depends.

But the Materials Age is more than the name of a troublesome roadblock. It is, or eventually must be, an orderly way of thinking about many seemingly diverse elements, such as the pullulating number and variety of engineering materials, the new end-use orientation in designing with materials, the new basic science of materials, the application to materials of the systems concept, and the growing practical field of materials engineering. Here, we believe, is the first attempt to put these elements into meaningful and logical order.

Our progress in space flight, in automation, in electronics, and in utilizing atomic energy is dependent on the solution of crucial materials problems. Likewise, in the less glamorous fields of industrial and consumer products, materials are now widely recognized as the critical factor that determines cost, quality and performance. Dr. W. O. Baker, vice president of research at Bell Labs, recently summed up the significance of materials in our present age this way: "Materials as never before must be the means through which man realizes his dreams of well-being on earth, or, failing that, liberation into space."

The Coming of the Materials Age

The rise again of materials from a relatively dormant role to one of major importance is a recent development. For several centuries the few metals and alloys, such as iron, copper, brass, tin and zinc, were sufficient to meet most of man's needs. And engineers were usually content to stay within the property bounds of these existing materials. There were exceptions, of course, such as in the power generating equipment field where better materials have always been desired for higher efficiencies, and in the automotive field where economics early pushed the search for cheaper materials. But, by and large, materials were adequate for the needs, and emphasis was on their mining, production and processing rather than their use and improvement.

The late 19th century and the beginning of the current one saw the birth of the new age of materials. Steel became the major material of engineering, aluminum became a commercial metal, Hyatt invented Celluloid, and Baekeland developed Bakelite.

From this modest start came a virtual revolution in materials. Where only routine progress had been made for centuries, new materials were now developed at an exponential rate. As the chart in Prof. Van Vlack's article shows, plastics and rubbers, practically unknown at the beginning of the century, have increased in variety several hundredfold and the rate is still increasing. The same is true of ceramic materials.

Even in the metals field, where the rate of development has been slower, hundreds of new alloys are becoming available every year. In Norman Woldman's book, "Engineering Alloys," 7000 new alloys were added to the third edition, which was published in 1954, seven years after the second edition. A total of 19,280 alloys are listed in the third edition.

Not only has the number of materials increased, but also the combinations. Clad metals, reinforced plastics, laminates and honeycomb materials have introduced the systems concept to the materials user. Now he can construct materials in which the best properties of two or more constituents will be used to advantage.

Materials—the Key and the Obstacle

With this new cornucopia of materials, engineers found new freedom in design. The engineer was now able to translate a much wider range of concepts and ideas into physical reality. And an unheard-of variety and complexity of mechanisms and products resulted.

Then, paradoxically, the time came when our technology began to grow poor amidst its materials riches. Engineers' imagination and their new devices began to outstrip the properties of existing materials. The complexity of products, the competitive market, the flight into space, the development of atomic

energy—all these and many other developments—imposed upon materials unprecedented demands. The result was that in more and more fields designers found themselves critically limited by the materials available to them.

In the past ten years these limitations have become particularly serious in the missile, aircraft and aerospace field where materials do not have the combinations of properties and the level and uniformity of performance required for space vehicles, power plants and weapons.

The anticipated requirements in the aerospace field further point up the critical importance of materials. For example, the service temperatures that refractory materials for long time service will have to meet within the next ten years will range from – 100 F to about 6000 F. And strengths required of metals will approach ½ million psi.

But it is not only in the fields of advanced technology where materials have become the key to progress. In almost every other manufacturing field, materials have become the major consideration in planning, designing and producing products. There is hardly an industry or a plant that is not searching for new or better materials to meet increasingly severe service conditions, to improve product performance, and to lower materials or production costs.

The New Orientation

The tremendous increase in the number of materials, coupled with the rise of new and more severe service requirements, is bringing about many changes in our ways of applying materials. Traditionally, the point of view of the user of materials was to fit the design or product to the properties of a material. This attitude has changed. The major concern now is finding and applying a material or materials with the right combination of properties to meet the design and service conditions.

Thus, the new attitude is end-service-oriented. The next logical step, of course, is tailor-made materials. As we will see later, definite progress in this direction is being made.

This new orientation is also being reflected in our approach to materials specifications. Whereas, most specifications were largely descriptive of a material, the trend is now to performance specifications. Thus, the user of materials has much greater freedom to select the most suitable material for his application. The future will probably see even greater changes in materials specifications. Specifications may be developed in terms of microscopic rather than secondary or macroscopic properties, so that the engineer can specify the precise behavior of materials he wants under a given set of conditions.

A Unified Field of Materials

We have seen how many and diverse forces brought about a renaissance in materials. But these forces have done even more. Along with advances in fundamental science, they have sparked the rise of a new technical field and discipline that is unique and characteristic of the new Materials Age. It is the *unified* technology of materials.

Thus, in the development and application of materials a synthesis of great significance is taking place. Traditional boundaries between classes of materials are being swept away. The specialization of the past that erected barriers among engineers and scientists who dealt chiefly with one kind of material is doomed. A more powerful approach, based on the proven proposition that the same fundamental concepts underlie the behavior of *all* materials, is rapidly emerging.

Among leaders in the education and technical world, it is widely believed that this movement toward a unified field of engineering materials is the most significant trend in science and engineering today; and that, though it is still in the formative stages, the next quarter century will see it rise to be the dominant discipline in our technology.

The Science of Materials

The foundation upon which the unified field of engineering materials is now building is the new science of materials. This foundation, it must be quickly stated, is as yet far from complete. Hardly more than the footings are now finished. Nevertheless, these beginnings have already demonstrated both the necessity and the advantages of a unified approach to the study of materials.

What is meant by the science of materials? An accurate definition for such a young field is difficult to devise, and there is not complete agreement among materials people on what it encompasses. Most commonly, it is closely identified with solid state physics, as the articles by Drs. Brooks and Krumhansl show.

But while materials science does lean heavily on solid-state concepts, it also uses knowledge from many other disciplines. Dr. Baker recently characterized materials science as "being constituted of the physics of crystals, mechanics, chemistry, metallurgy and of many diverse resources of mathematics, statistics, electronics and certainly of dialectics."

Thus, out of this complex of many disciplines is emerging the unified science of materials whose principal aim is to explain the properties of materials in terms of molecular or crystal, atomic and subatomic structure.

At first glance it is difficult to see why it has taken so long for a science of materials to develop. Certainly it has been known for a long time that all materials are composed of the same basic building blocks—atoms. But it has not been well-known for very long that the way in which the atoms are arranged in a solid largely determines how that solid will behave. Traditionally, the chemist empirically correlated composition with properties and the metallurgist related metallurgical phases to the performance of his metals. A unified science approach to materials had to wait for the workers in these separate fields of materials – metals, ceramics, polymers—to fully recognize and understand that structure as well as the atom is the common denominator of all materials.

But what is the practical use of all this fundamental knowledge? Perhaps its most important application is as a source from which the field of materials development can draw knowledge to invent new materials. For, once the relation of structure to properties is known, we then have the means to control that structure and to give us the exact properties we want. As Prof. Arthur R. Von Hippel has said in discussing "molecular engineering" (another name for materials science): "Instead of taking prefabricated materials and trying to devise engineering applications consistent with their macroscopic properties, one builds materials from atoms and molecules for the purpose at hand."

So the engineer, Prof. Von Hippel says, "can conceive devices based on ideal characteristics and then, returning to the laboratory, inquire how far such characteristics can be made to order. He can play chess with elementary particles according to prescribed rules until new engineering solutions are apparent. He can be selective by insight, foreseeing inherent limitations of materials and making use of their actual capabilities."

Thus, we no longer must accept the atomic arrangements nature gives us. Such, for example, is the case with high polymers—those aggregates of giant, chain-like molecules. High polymers that nature gave us, such as wood, leather and glue, have been used as engineering materials for centuries. But only during the past couple of decades have we acquired sufficient understanding of their molecular structure to improve on nature. Now, by varying the chain length and degree of branching or crosslinking, materials can be produced with combinations of properties to meet specific application requirements.

Materials Engineering

As is evident from the above, the greatest impact of materials science has been on the materials development field. Its influence has only begun to touch materials application practices. Much work is still required to correlate structure-sensitive properties at the microscopic level with those at the macroscopic or engineering level. As this is accomplished, materials science will increasingly influence and eventually govern materials application practices. For the present the science of materials marks the new unified approach to materials only at the basic science and development level. It is the emergence of a new technical specialty, materials engineering, that characterizes the modern approach to materials at the application and engineering level.

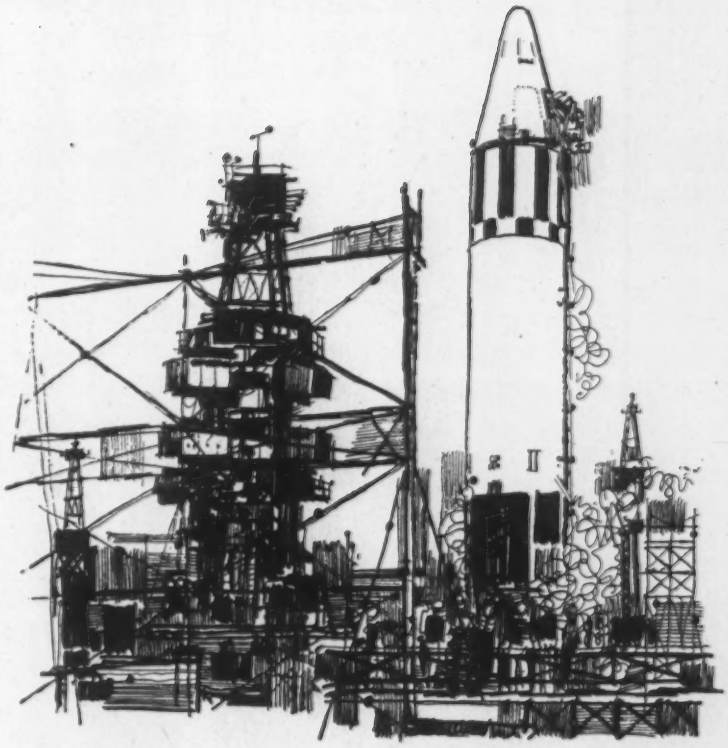
As just pointed out, the initial impetus to materials engineering did not come from materials science, as is often supposed. It arose, rather, as a natural and practical response to the major problems and trends that were described in the first part of this article. Thus, as the critical importance of materials grew and as more and more materials were introduced, it became evident that the dispersed and routine attention generally given to the application of materials was no longer satisfactory. It was now necessary to have a better working knowledge of materials – their properties, their economic factors, their processing characteristics, and their response to the conditions of service. Also, the multiplicity of new materials had far-reaching effects on processing and fabricating

techniques. Established forming, casting, machining, and joining practices had to be modified or new ones developed.

This extensive know-how could not be gained by a number of different people giving part-time attention to materials. A technical person or group who could spend full time on materials activities was needed. It was this need that started the trend to a more unified approach to materials application in industry. And, as a later article on materials engineering points out, more and more companies are now centralizing their materials activities in materials specialist groups.

Though materials specialists are handling many of the materials application problems today, a great many designers and engineers are and will continue to be vitally involved with materials. And the new importance of materials is requiring them to devote more time and attention to the proper application of materials.

By training and experience most engineers are oriented toward the straight design and the mechanical or electrical aspects of product development and design. But to successfully design most products today, the design engineer can no longer be just a designer or a mechanical or an electrical engineer. He must, in many cases, also function as a materials engineer. There are many indications that the trend in design engineering is in the direction of more and more emphasis on materials. One of the strongest indications of the trend is the increased attention being given to augmenting engineers' education in materials.



The Future of the Materials Age

The Materials Age, as we have described it, is here, and it will be with us for a long time to come. Our future technological history will be dominated by materials even more than it is now—dominated by materials that we can hardly imagine. No longer shackled by empiricism and by the external and macroscopic approach, materials will become the actual objects of our designs. They will be designed as end-products and made to perform the functions of components or mechanisms, typified today by the transistor and by the recent developments in molecular electronics. Thus, it is conceivable that our future refrigerators will consist merely of a shell and shelves that in themselves provide the cooling and insulation. And the complex power steering mechanism in today's cars may be reduced in future years to a simple-looking block of material.

So, the era of Newtonian engineering, largely concerned with the external manipulation of gross masses, has about reached the limits of its usefulness. The practice of dealing only with the external aspects of the "black box" must give way to the new and more fruitful one of designing the internal architecture and manipulating the molecular domains, crystals, atoms and electrons so as to give the precise output desired. Herein lies the future of the Materials Age. *—H. R. Clauser*

Materials Science: The Role of Solid State Physics

by Harvey Brooks,
Dean of Engineering
and Applied Physics,
Harvard University

Underlying the brilliant promise of the Materials Age—but also posing some of its thorniest questions of education and organization—is the science of materials. Although this new science brings many disciplines — including mathematics, mechanics, chemistry and statistics — to bear upon the fundamentals of materials, it is perhaps the discipline of solid state physics that is bringing about the most immediate and most revolutionary changes in the way we look at materials. Here, a physicist explains what the solid state approach tries to accomplish and urges us to accept the benefits of this new science in developing materials to meet today's new needs.

The impact of solid state science on engineering materials is reflected on three distinct levels. It has made possible:

1. Discovery of completely new and perhaps novel materials.

2. Major or minor improvements in existing materials that come only with a more complete understanding of the nature of the materials and their properties.

3. Understanding the ultimate theoretical limits to the properties of materials before they have been attained practically.

Adapted with permission from "The Science of Engineering Materials," John Wiley & Sons, Inc., 1957.

The development of the transistor is a particular example in which a completely new material with new properties and new applications resulted from fundamental advances on the more theoretical side. A similar example is provided by the field of magnetic materials where fundamental advances in the understanding of magnetic domains and the magnetization process caused a completely new class of materials, fine particle magnets, to be *invented*.

In addition, there are numerous examples in which the fundamental approach of solid state science has made possible improved understanding of the nature of various properties of materials and has paved the way for improvements in the properties themselves or widened the horizons of the applications for already known materials.

Tremendous advances also may be expected to flow merely from the application of systematic scientific analysis to materials and processes already in current use, and new materials and applications are most likely to result as a by-product of the deeper understanding and investigation of current practical developments. This has already been the pattern of the past in the fields of semiconductors and magnetic materials. These and other practical applications of advances in solid state physics will be discussed in the next article.

How Did the Solid State Approach Arise?

As a recognized branch of physics, solid state physics arose as an outgrowth of the application of quantum ideas to various problems of the crystalline state in the late '20's and early '30's. Many of the outstanding accomplishments of the new wave mechanics found their application in the explanation of various solid state phenomena. Indeed, the experimental foundation of wave mechanics lies in the classic electron diffraction experiments of G. P. Thomson, and of Davisson and Germer, which were really solid state experiments. These opened the way not only to the understanding of the wave nature of matter but also to an important new tool for studying crystal structure and especially crystal perfection in surface structures.

Early successes of quantum theory in the field of solids included the explanation of the origin of ferromagnetism by Heisenberg and Bloch, the correct explanation of the origin of electrical resistance in metals, the introduction of the concept of positive charge carriers by A. H. Wilson and consequent interpretation of some hitherto anomalous galvanomagnetic effects, the first successful theories of the cohesive energy of metals by Wigner and Seitz and by Fuchs, the explanation of field emission from solids, the first understanding of the reason for the importance of the electron-atom ratio in determining the phase boundaries of alloys as formulated by Jones, and many others.

What Does Solid State Physics Try to Do?

Ideally the solid state physicist focuses his attention on the simplest materials: pure single crystals of the elements. From this point he

proceeds to an understanding of the influence of impurities, the influence of imperfections in microstructure, and from there to properties of alloys and compounds. This is the characteristic pattern of development which has been most ideally exemplified by germanium, but will be repeated in material after material.

Thus, the principal aim of solid state physics is to explain the physical properties of solids in terms of their atomic and electronic structure. A secondary aim is the explanation of the technical properties of solids in terms of the basic physical properties of primary constituents such as magnetic domains or crystal grains. As theory has developed, the field has tended to touch on more and more topics that were formerly considered the exclusive province of such closely related sciences as physical metallurgy and ceramics. This branching out to include new areas is characteristic of the subject because as fundamental knowledge grows it becomes possible to apply atomic ideas to problems that previously could only be approached from a phenomenological, or descriptive, point of view.

Because of the increasing unification of the viewpoint of solid state physics proper with that of physical metallurgy and of other specialized material sciences such as ceramics, glass technology, and high polymer physics, it is becoming customary to link all these specialties together in the common term *solid state science* insofar as the topic of major concern is the relation between atomic and electronic structure and macroscopic properties of atomic aggregates. Of course, these special sciences cover a much wider area, which includes the special techniques and processes peculiar to each type of material.

Structure-Insensitive and Structure-Sensitive Properties

In order to better appreciate the role of solid state science in furthering our knowledge of materials and their uses, it is convenient to divide the properties of materials into the structure-insensitive, or intrinsic, properties, and the structure-sensitive properties. Structure-insensitive properties are those which are thought to be characteristic of a perfect single crystal of a solid or of the chemical constitution of noncrystalline materials; structure-sensitive properties are those which are seriously influenced by small degrees of imperfection, including trace impurities.

Using this classification, the science of solids naturally divides itself into two parts. One part is concerned with rationalizing the structure-insensitive properties in terms of atomic and electronic concepts; the other is concerned with how the structure-insensitive properties, regarded as "given" for individual building blocks, are synthesized to produce the structure-sensitive properties. For example, given the elastic and plastic properties of single crystals, how do we explain and predict behavior of a polycrystalline aggregate?

From the technological point of view the structure-sensitive properties are generally of more immediate interest. But these are also the most difficult to understand in a really quantitative way.

The gap between the properties of individual atoms and electrons and those of aggregates may be at least partly bridged by suitable approximations. It is possible to consider an electron in a metal as moving in a force field created by all the positively charged ions which are regularly disposed in a periodic fashion in a metal crystal. If the force field has a perfectly regular periodicity, then the possible energies of the electron may be computed, at least to a certain approximation, leading to a qualitative understanding of such properties of metals as electrical and thermal conductivity. More quantitative calculations lead to a theoretical understanding of intrinsic properties of metals, such as their cohesion and specific heat.

If deviations from perfect periodicity are encountered, calculations become more difficult but may still be carried out to a sufficient approximation in some cases; for example, electrical resistance of metals can be understood from a theoretical point of view in terms of various types of imperfections in the crystal lattice, including thermal vibrations. On the other hand, qualitative understanding of many structure-sensitive properties is not available, especially in cases where the properties depend upon complex relationships between imperfections, as is true of mechanical properties of metals and other solids.

Solid State — Past, Present, Future

Most of the common materials being used today have been developed

over the centuries by pure art, and the early effort of solid state science was directed at trying to rationalize, in terms of the new theoretical concepts, facts and properties that were already well-known to the technologist and the engineer. It is perhaps for this reason that the new science has, until after World War II, attracted little attention among engineers. Many of the important developments in the fields of new metals, semiconductors, magnetic materials, dielectrics and ceramics have been the result of trial-and-error or "statistical" methods of research with little benefit from the advancing science of the solid state.

On the other hand it should be emphasized that not only has solid state science advanced the various materials sciences but also that many important fundamental advances in solid state would have been impossible without the aid of the rapidly advancing technology of materials which has its scientific foundations, for the most part, in classical thermodynamics and classical inorganic chemistry. The preparation of ultra pure materials, the controlled addition of minute concentrations of impurities, and the growth of nearly perfect single crystals have been among the indispensable techniques of progress.

The years following World War II have seen the emergence of many elements into technological importance. Germanium has helped to revolutionize electronics. Titanium is providing the foundation of a whole new light metal technology comparable to that of aluminum but in more specialized fields. Zirconium has been transformed from a laboratory curiosity to an important substance that is the basis of an atomic power technology.

The entire nuclear program was founded on two metals — uranium, a relatively rare and unknown curiosity in 1940, and plutonium, an entirely man-made chemical element. When these two metals became important, almost nothing was known of their chemical and physical properties, and solid state science was relatively powerless to predict their properties.

There are other metallic elements whose properties and potentialities, now that they are available in pure form, are only now being realized. Rhenium and vanadium are two examples.

The lesson in this catalog of new materials is that for years the engineer relied on certain old standbys such as the steels in all his structural designs or on iron-silicon alloys in his magnetic designs. Rare or hard-to-find metallic elements remained scientific curiosities. Now, suddenly, a host of new materials has appeared on the scene with too many possible combinations to enable all possibilities to be exhausted purely by trial and error, a fruitful avenue of progress in the past. Trial and error will always be the ultimate arbiter, but more basic principles are needed to guide us on what to try, and how to proceed from preliminary success to further improvements.

At the other end of the scale from metals are materials that the physicist would like to ignore, but which the engineer cannot afford to:

the complex synthetic materials and organic materials. The pattern of progress in these fields is more difficult to forecast or generalize. Technology, actually, is little beyond the stage of recognizing the relation between chemical composition and properties, the stage in which steel, for example, was in the last half of the 19th century before the realization and exploitation of microscopic structure analysis. With more complex materials, the problems are immeasurably more difficult and will take all the resources of modern techniques to solve.

The Practical Results of the Solid State Approach

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The significance of the relationship between the materials of engineering and the often abstruse concepts of modern physics is not merely theoretical. In the electronics and instruments fields, particularly, the relationship has for a long time been an intensely practical one. The whole applied science of semiconductors is founded on investigations into the atomistic effects of impurities. Entirely new classes of magnets have been developed from fundamental principles concerning particle size and electron spin energy.

The breadth of application of the principles involved in these and other advances discussed by the author suggest that the solid state revolution in the field of materials has only begun.

As Dr. Brooks pointed out in the preceding article, solid state is one of the basic sciences in the complex of materials science. Pure sciences, such as physics and chemistry, have constantly been closing the gaps in areas of basic ignorance while the applied sciences, such as metallurgy and ceramics, have been investigating gaps in the understanding of materials or processes of more immediate utility.

Many of the developments in the field of solid state physics over the last two decades have only recently been applied. The expanding role of solid state investigations in the technology of materials is shown in the examples that follow later in this article. When the basic concepts of the solid state are assimilated in the training and practicing intention of the materials engineer, the practical result will be a broad spectrum of super-property materials and functions.

In the use of materials for structural or "hardware" purposes the two primary questions encountered are how to form the material and what are the mechanical properties after forming. Long before solid state physics, metallurgists and chemists developed an extensive body of knowledge within the framework of their particular scientific disciplines. On the other hand, it became increasingly clear over the years that such puzzles as the variability of the strength of steel with apparently similar processing methods, and the sensitivity of processing techniques to small amounts of impurities, could not find adequate explanation within the existing traditional framework.

The solid state approach has been able to show why some of these things are as they are. It has been able, to some extent, to postulate fundamentally new recipes for the synthesis of fundamentally new materials with completely new mechanical properties. Principal contributions, however, have been centered around an understanding of imperfections in solids and their identification with properties which can be called "structure-sensitive."

Example No. 1 — How Diffusion Works

One of the most important mechanisms, technologically, that has been

advanced in understanding is diffusion in solids. Both self-diffusion and the diffusion of chemical impurities are essential steps in many metal processing techniques; in addition, diffusion is the primary mechanism in determining many aging or time-dependent property changes. The cooperative work of metallurgists and physicists over the past decade has made it quite certain that diffusion takes place in structural materials either because of vacancies in the crystal lattice, or because the crystal lattice can accommodate interstitial atoms of its own kind or a solute species. An understanding has been developed of how much energy it takes to form such defects, how the concentration of defects varies with temperature and composition, and similar questions—but only in a limited number of materials.

The result of this understanding has been to give much more quantitative guidelines to process design in powder metallurgy and ceramic technology, at least in those materials for which the basic parameters of the defects are known. The role of fluxes in ceramic processing has become clear. Recently a sintered alumina of such high density and homogeneity that it can be used in noncritical optical applications has been produced by the application of these concepts (see M/DE, Nov '59, p 143).

Example No. 2— Dislocations and Strength of Materials

Perhaps the most publicized kind of imperfection studied in the recent work on mechanical properties of materials has been the dislocation, a "line" type of defect rather than the "point" defect important in diffusion. First suggested in the early 1930's to explain the discrepancy of a factor of 1000 between the ideal cohesive strength and the much lower observed strengths of materials, this concept has received extensive verification, both visual and inferential, during the last several years. In the course of this development, there has been a very satisfying application of knowledge from many branches of solid state. Here, very briefly, are some highlights:

1. It has been possible to make direct visual observation of dislocations, either by etching techniques which locate the emergence of dislocation lines at crystal surfaces, or by internal "decoration" with solute atoms of dislocations which makes possible direct observation by light or electron microscopy. In a few materials, dislocations have been studied before and after the application of stresses. The expected behavior under plastic deformation has been almost completely demonstrated.

2. On the basis of the dislocation concept and the interaction of this imperfection with other imperfections in the solid it has been possible to understand yield point phenomena, precipitation hardening, the nature of small angle grain boundaries, and a host of other phenomena. Moreover, the mechanical properties of whiskers, or small dislocation-free filaments, do display behaviors approaching the high performance predicted by theory. As yet these properties have not been obtained in bulk materials.

Perhaps solid state science can make some contribution to the ultimate extension of these advances on the microscopic scale to bulk practicality, but it would be unrealistic to expect miracles.

Example No. 3— New Magnetic Materials

Ferromagnetic materials are the basis of many electrical engineering applications, from power generation to microwave electronics. As in semiconductors, but to an even greater degree, an art has grown up over the years on which there has been little direct impact of solid state science. Even though the basic discoveries of new materials have been largely empirical, however, solid state science has begun to contribute substantially to their improvement. The energies involved range from 10^{-1} electron volts, the exchange energy per electron in a ferromagnetic material, to 10^{-8} electron volts for nuclear magnetic phenomena.

Fine particle magnets—One of the most interesting recent developments of practical usefulness is the fine particle permanent magnet. In 1930, Frenkel and Dorfman predicted that below a critical particle size (about 150 angstroms) a particle would consist of a single magnetic domain having the theoretical saturation magnetization. If elongated fine particles could be made, the resulting anisotropy could stabilize the magnetization along the particle axis. If these particles were then ordered in a matrix, the result would be a permanent magnet material with high magnetization and high stability.

Although the concept was stated by a physicist in 1930, it was not until about 1958 that metallurgists and chemists provided the ingredient that the physicist could not: the development of electrolytic processing techniques that could produce particles of the desired size and shape from the proper material. In this case, solid state investigations led to a new material specification and properly predicted the properties, but realization of these required the services of other disciplines in an equally essential way.

Ferrites—Another class of materials that evolved from close cooperation by solid state physicists and inorganic chemists is the group of ferrite magnetic materials. Using the mineral form $FeO \cdot Fe_2O_3$ as a basis, a substitutional chemistry of divalent ions, such as magnesium, or trivalent ions, such as aluminum, can be substituted for the divalent and trivalent iron ions. This concept led to the synthesis of a wide variety of magnetic materials, from magnetically soft materials of low electrical conductivity (with widespread application as core materials in communication electronics) to magnetically hard materials (which found application in computers). These useful materials are a direct outgrowth of such basic studies as the magnetic moments carried by each ion, the interaction between the ions, and resonance methods to study the precession of the magnetic moments of the ions and their interaction with each other and the lattice.

Magnetic garnets and parametric amplifiers—From the studies of static magnetic properties, a new class of materials based on the structure $5A_2O_3 \cdot 3M_2O_3$ has been developed. In these magnetic garnets the substitutions for A and M are rare earths such as yttrium and transition elements such as iron, with a wide latitude for magnetically inactive substitutions.

The resonance properties of YIG, yttrium iron garnet, are particularly interesting. Because the spin system is so weakly coupled to other energy absorbing mechanisms in the solid, it is possible to build up the energy in a resonant spin system to a high level with only moderate energy input. When this happens, we find nonlinear effects that are widely useful for modulation and generation of electrical signals.

The result has been to stimulate the development of a whole new branch of communications technology under the generic classification of parametric amplifiers. Functional principles of parametric amplifiers have been known for some time, and they have been applied in magnetic amplifiers for use at low frequencies. With these new materials it is now possible to make low noise amplifiers and oscillators for use over a much wider range of frequencies and signal levels.

Masers—Closely related to fundamental studies of magnetic ions at low dilution in magnetically inactive salts is the development of the maser. Here again basic studies led to the realization that it was possible to pump between energy levels of such ions and disturb the populations of these levels from their thermal equilibrium occupation probabilities to such an extent that, when properly stimulated, they would emit, rather than absorb, radiation (thus *m*icrowave *a*mplification by *s*timulated *e*mission of *r*adiation). The materials problem here is a combination of crystal chemistry of the matrix and the physics of small concentrations of an added solute species. The maser is very important in communications and space technology because of its low noise and stability.

Example No. 4—Thermoelectricity

Developments in semiconductors have been purposely avoided in this article since the transistor, particularly, has received so much publicity. However, this brief review would be incomplete without reference of the subject of the moelectricity and energy conversion. Solid state physics is contributing to this technology in helping to select materials with high thermoelectric power and low thermal conductivity. While these devices are not as efficient as mechanical large scale power generation or refrigeration methods, it seems certain that their versatility will lead to wide use.

The use of isoelectronic substitution to lower the thermal conductivity of a thermoelectric material is a good example of the application of basic principles. The point is that the heat current in most thermoelectric materials is carried primarily by lattice vibrations, and the substitution of an ion with different mass, but the same valence, can scatter these waves and increase the thermal resistance without strongly affecting the electronic

properties. Thus, $Bi_2Te_{3x}Se_{3(1-x)}$ alloys can be made with thermal conductivity several times lower than that of either the pure telluride or selenide.

Solid State and the Future

Many other examples of recent applications could be cited – tunnel diodes which do not require ultrapure semiconductor materials; solar cells which are so important for satellite power supplies; piezoresistance strain gages using germanium; an understanding of the silver halide photographic process and new processes such as xerography; electroluminescent light sources; cryotrons and low temperature computing devices using the superconducting properties of some materials.

There are also a host of peripheral sciences in which the concepts of solid state have only been slightly used. To mention a few: the chemistry of catalysis; excitation transfer and electronic processes in photosynthesis; and the "solid state" of noncrystalline materials.

One can hope that solid state science will leave its mark in some of these other fields. But while in both training and practice we should maintain an interdisciplinary awareness of the practical import of our work, solid state is a basic science showing no signs of running out of motivation for discovery within itself. If there is one challenge which this indicates for the years ahead, it is the challenge to the engineering scientist to modify the traditions in his training and practice to allow more room for the approach of the physicist in the practically infinite spectrum of materials problems.

TYPICAL ENERGIES OF SOLID STATE PHENOMENA

Energy Range, electron volts	Physical Phenomenon
10 ↓ 1	Cohesive properties Ultimate strength
10^{-1} ↓ 10^{-3}	Energy for forming point defects, vacancies and interstitials Activation energies for diffusion Elastic strain energies at yield of practical materials Dislocation energies Electronic energies in thermoelectric and semiconductor electronic devices Exchange energies in ferromagnetic material Infrared detectors
10^{-3} ↓ 10^{-6}	Electron spin resonance — masers Ferromagnetic resonance — mavars Cryogenic devices Nuclear resonance applications

Reaction Energy Sets Boundaries

Briefly, the energies of solid state phenomena per unit involved (atom, electron, light quantum, etc.) range from 10 electron volts at the upper end of the scale to 10^{-6} electron volts at the lower end.

High reaction energy—*Chemical binding energies range from 1 to 10 electron volts per atom. Elastic strain energies, at the yield point of typical materials, are one-thousandth of the cohesive energy per atom. Thus, chemical and metallurgical phenomena lie at the upper end of the energy scale.*

Moderate reaction energy—*Energies of electronic phenomena involving the transport of electrons may, speaking in a broad sense, lie between 10^{-3} and 1 electron volt. At the upper limit such electronic phenomena find use in power generation and conversion (thermoelectric devices and power rectifiers); at the lower limit are communications and information handling applications.*

Low reaction energy—*At the low energy end of the spectrum of solid state are phenomena involving electron and nuclear spins, with energies from 10^{-4} to 10^{-6} electron volts. It is possible to say with certainty that the practical applications that grow out of the solid state studies of these phenomena will be in the handling of information with a minimum of energy expenditure and a maximum of speed, since the phenomena involved only require spin flip, rather than transport, of electrons.*

In the accompanying table some of the applications to be discussed are classified according to energy.

The Rise of Materials Engineering

If the emerging science of materials is the most significant characteristic of the Materials Age to scientists, the growing discipline of materials engineering is surely the phenomenon of most significance for many engineers and for engineering management.

Before World War II, with few exceptions, departments of materials specialists or materials engineers simply did not exist in industry. With the explosive growth in materials that started during the war, however, many companies have found it necessary to realign the engineering organization to insure that men and groups with broad knowledge of all materials were available in all planning, design and production stages. The result has been the rise of a new engineering specialty commonly called materials engineering.

Here is its philosophy and a look at how it works in industry.

The new specialty of materials engineering, which is also called materials and process engineering, is still evolving and so its functions and scope are not yet too clearly defined. But, in general, it encompasses the many activities involved in applying engineering materials in the design and manufacture of products. Its aim is to bring to bear a thorough knowledge of materials at all stages of the planning and manufacturing cycle in order to produce high quality products at the lowest possible cost. Thus, where a materials engineering group exists, it is the control center for the materials going into a product. It starts operating in the preliminary design stage and continues throughout production design and actual manufacture.

Although it is one of the youngest of the technical specialties in modern industry, materials engineering is growing rapidly and already has become an essential part of many manufacturing organizations. Today at least one out of two medium or large size plants has a materials engineering group or department. Twenty years ago only one out of ten manufacturing plants had a group whose primary job was engineering materials. At the present rate of growth, within the next ten years we can well expect that three-quarters of all medium and large size concerns will have in their technical organization a group specializing in the development and application of materials.

The above facts and others to be reported in this article come from a survey conducted recently by M/DE. Covering 110 plants in the principal product manufacturing fields, the study provides an up-to-date and comprehensive picture of how industry is handling its materials problems and how it is meeting the challenge of the Materials Age.

Before Materials Engineering

Because nothing can be manufactured without using materials, it is a wonder that materials engineering as a function in its own right has been so long in developing. Prior to World War II materials engineering was virtually unheard of. Only a few companies paid more than a modicum of attention to practices

and procedures for the efficient application of materials. And fewer still had a systematic approach to, or a centralized group to handle, materials activities.

The prevalent attitude in most plants was, in effect, "materials are everybody's business." Consequently, individuals in development, design, manufacturing and purchasing handled materials problems, each in their own way, and often as an expedient or necessary evil. Designers and project engineers, in particular, had to handle materials problems as best they could. Many firms, of course, have always had a chemical or metallurgical laboratory, or plant metallurgist or chemist. But, traditionally, their work has been specialized either in only one materials area, such as stainless steels, or in only one functional area, such as metal finishing or welding. However, in many plants where chemical or metallurgical departments already existed, the functions and responsibilities of these departments have now broadened so that they are now truly materials engineering groups.

There were, of course, many reasons for the slow evolution of materials engineering. A number of them, such as the small number of available materials and the lack of a unified field of materials, have already been covered in the first article. Another reason, but a false one, frequently mentioned is that the cost of materials is relatively low in comparison to that of labor. Actually, the cost of materials generally ranges between one-third and one-half of the total manufacturing cost. A much more valid reason is that top and engineering management just were not aware of the advantages of a centralized materials engineering function.

The Birth of Materials Engineering

It took the materials shortages of World War II to create the need and demonstrate the value of materials engineering as a distinct technical function. Where before materials were taken for granted and no special thought given them, the use of substitutes for unavailable "standard" materials now made industry aware of the potentialities of other materials. And in adopting different materials, industry had to face and solve a host of processing problems. With the increased number of materials also came the need for standards and specifications to cover them. In many cases no material or industry-wide specifications existed. And even where they did exist it was necessary to develop company specifications to meet special and individual requirements.

Out of all of this came a new awareness of the range and variety of materials that should be considered when planning a new product or redesigning an old one. The new awareness of materials, in turn, pointed up the advantages of having materials specialists or departments that could devote full time to materials and coordinate the materials problems that arise in design and manufacturing.

Both the aircraft and automobile industries were among the first to appreciate the value of a central group specializing in materials, but each for a different principal reason. Because the automotive industry is extremely cost-conscious, its principal motivating factor was reduction in both initial materials cost and cost of production. Of course, an important by-product of central materials engineering was improved materials performance. To aircraft producers, the need for higher and more reliable materials performance and the desire to avoid catastrophic service failures were the main reasons for early acceptance of central materials groups.

It is this critical dependence on high-performance materials that has caused the aerospace industry to proceed faster and further than any other industry in developing and using materials and process engineering departments. Today few, if any, aircraft plants are without a large, multi-section materials department. Well-organized and often employing as many as 300 to 500 materials specialists and engineers, an aircraft materials department is a key group and the control center through which all materials problems in development, design and production flow. The growing demand in practically all other product manufacturing fields for higher performance to meet unusual and severe service conditions, and the demand for lower manufacturing costs, have prompted other companies to follow the lead and pattern of the aircraft industry. The result, as stated earlier, is that over 50% of medium and large size manufacturing companies now have materials groups.

Although materials departments are most commonly found in the large and medium size organi-

zations, studies have shown that a surprising number of small firms also have materials departments. Plants employing as few as 500 persons have found that good use can be made of materials application specialists.

The size of materials engineering groups varies widely and depends chiefly on the size of the company and on the relative importance or emphasis given materials in the engineering picture. The M/DE study showed that 46% of the materials engineering departments employed 2 to 10 technical people. About 35% had between 11 and 100 people; about 20% employed over 100 technical people; and as many as 10% of the departments employed over 200.

Materials Engineering Today

Organization of materials departments—Since the materials engineering function is relatively new, there are still questions as to where it best fits on the organizational charts. It is recognized, though, as being predominantly an engineering function, and the M/DE study showed that in 75% of the companies, the materials group is a service department in the engineering division. However, in about 20% of the firms, the groups report directly to management. Regardless of where it fits organizationally, a materials engineering group usually provides its services to all engineering and operating divisions, including research, manufacturing, maintenance and purchasing.

Although not too common, some extremely large plants operate materials groups in each of several major departments. Thus, materials groups may be set up in engineering, research and manufacturing. Also, some large, multi-plant corporations have a materials group in each of their plants or operating divisions, as well as a central materials engineering group on the corporate level. Such central groups, in addition to assisting the smaller plant groups, work on broad materials problems and generally devote a large share of their efforts to materials development.

While materials engineering itself is an engineering specialty, there is also specialization within materials groups. At least this is the case in the medium and large size departments. The most common method of organizing materials departments is by materials. Seventy percent of the materials departments surveyed are organized principally by type of materials. Usually there are separate specialists or sections devoted to metals, nonmetallics and processes. However, in 25% of the companies the materials department is sectionalized by property, by service area or by product. And a few are organized by function, such as research and development, materials application, and standards and specifications.

As would be expected, the detailed form of the organization is almost always dictated by the nature of the company and its products. And more often than not, it is a combination of the several types of organizations just discussed.

What materials engineering groups do:

1. *Select materials*—Perhaps the most important function that materials engineering groups perform is selecting or aiding in selecting materials. All of the materials groups questioned in the study said that they perform this function. And 75% of them also analyze existing products and suggest materials changes to improve performance or reduce costs.

This materials selection function is performed in several ways. Frequently the designer or project engineer takes the initiative and consults with the materials department. In other cases the preliminary and final drawings, the bill of materials, and the specifications are reviewed by the materials group.

Another procedure is for the materials engineering department to specify materials that will meet the service requirements as set forth by the design department. One large aircraft engine plant, for example, uses this procedure: The materials section is furnished with a list of engine components along with the service and environmental requirements to be met. The materials group then determines the materials to be used and, in addition, develops exact property data. The design group then redesigns making use of this property data. Finally, redesigns are then routed through the materials group for review and approval.

2. *Evaluate new materials*—Closely related to the materials selection function is the job of keeping abreast of all new materials developments and of evaluating them to determine whether or not the company can use them to advantage. When a new material does show promise, it must undergo further evaluation

and testing. Seldom can a material be adopted before a wealth of essential design and performance data is accumulated by the materials department. In addition, fabricating, processing and finishing information must be gathered. In many cases, new or modified processing methods must be developed before the new material can be released to production.

3. *Develop standards* – Of all the tasks performed by materials groups, the development of standards and specifications is among the most important. Specifications are the major tools of materials engineering. They are indispensable for controlling the selection, purchasing and processing of materials. They outline property, quality and processing requirements. It is the job of materials engineering to prepare and interpret them, and to see to it that they are complied with.

4. *Maintain suppliers lists*—Developing and maintaining approved suppliers lists is another function frequently handled by materials engineering. There is usually one such list associated with each specification, containing the names of suppliers whose materials have qualified under that particular specification. The lists, therefore, provide control over quality.

5. *Disseminate information* – Directly tied in with specifications work is the job of collecting, digesting and distributing materials information to all interested personnel in design, engineering, manufacturing, inspection and purchasing. In the broadest view, specifications and informational documents, such as materials and process manuals, represent the sum and substance of nearly all the work performed by materials engineering groups. It can be seen, then, that the materials group in any company is the center and the source of sound materials data and information.

6. *Develop new materials* – All of the functions thus far discussed are directly concerned with the application of new or existing materials. Another materials engineering function, which is growing in importance, is the development of new materials or the modification of existing ones to solve special design or fabrication problems. According to the M/DE study, about 75% of all materials engineering departments now perform some materials development work. Many of the large departments spend as much as half of their time and budget in seeking new materials or developing new materials fabrication and processing techniques.

There are many examples of materials developments that have come out of materials engineering departments. Most of the early development work on semiconductor materials was done at Bell Laboratories and by others in the electrical industry. A number of jet engine alloys have been developed by Westinghouse and General Electric. Together with the National Bureau of Standards, the aircraft industry did much of the early development work on ceramic coatings. More recently, materials groups in the aircraft field have developed improved sealants and new emissivity coatings, and they are now doing most of the advanced work on filament wound reinforced plastics.

It is quite likely that materials development will continue to grow as an important and widely practiced function of materials engineering. Materials producers are reluctant to spend time on developing materials for narrow or specialized applications. Therefore, materials users will find it increasingly necessary to take on the job. Likewise, the trend to composite and combination materials will further stimulate materials engineers in the area of materials development.

Typical materials engineering departments:

■ The Materials Laboratories at Westinghouse Electric Corp. are one of the oldest and largest materials engineering departments in industry. They exemplify the highly developed materials organizations to be found in many giant, multiplant corporations.

The Materials Laboratories are one of three groups making up the central research and engineering complex at corporation headquarters in Pittsburgh. The other two laboratories are Research and New Products. The director of the Materials Laboratories reports directly to the vice president–research.

Besides these central materials laboratories, each of the major Westinghouse plants has a materials group to handle the work directly related to the plant's products. The central materials laboratories devote their efforts chiefly to broad problems that are of concern to more than one division, and to problems that the plant materials groups are not equipped to handle.

Employing over 420 people, of

THE DEPARTMENTS AND SECTIONS IN THE MATERIALS LABORATORIES AT WESTINGHOUSE ELECTRIC CORP.

Metallurgical Engineering Department
Ferrous Application
Nonferrous Application
Alloy Development
Powder Metallurgy Development
Metallographic Laboratory
Metals Processing Laboratory

Insulation and Chemical Engineering Department
Insulation and Chemical Application
Insulation and Chemical Development

Radiation and Nucleonics Laboratory

Magnetic Engineering Department

Ceramics Department

Solid State Electronics Engineering Department
Solid State Electronics Analysis
Solid State Electronics Development

Composition and Performance Department
Composition Laboratory
Performance Laboratory

Experimental Design and Statistical Analysis Department

Standards Department

whom 45% are technical graduates, the central laboratories are organized into nine departments as shown in the accompanying chart. As would be expected, the organizational setup reflects Westinghouse's major interest in electrical products.

The breakdown within the major departments indicates the two broad kinds of work performed in the laboratories: materials development and materials application. Some of the materials application work includes:

1. Evaluating new materials to see how they might fit into the products the company is now making or might be contemplating.

2. Solving processing problems that stem from the properties or characteristics of the materials being used.

3. Developing property data and preparing company specifications based on this data.

4. Providing technical assistance to design and materials engineers in the various plants and to the purchasing department.

The development work performed by the laboratories can originate in the research laboratories, in the Materials Laboratories themselves, or from a source outside the corporation. In addition, the laboratories carry out pilot plant operation to supply other divisions of the corporation with experimental quantities of materials that are required in developing new products.

■ In sharp contrast to the materials engineering department of a giant corporation is the one-man materials operation at Duncan Electric Co., a watt-hour meter manufacturer employing under 1000 persons. Here, the one materials engineer services both the engineering and production departments. He performs on a much smaller scale most, if not all, of the materials application functions listed above for Westinghouse's materials operation.

During the design period, the design engineers frequently consult with him, and he checks the materials and finishes selected for their service properties and for their production suitability. The materials engineer also writes the specifica-

MATERIALS ENGINEERING IN INDUSTRY: SUMMARY OF SURVEY FINDINGS

	%
Companies Having Materials Groups	52
Number of Technical People in Materials Groups:	
2 to 10	46
11 to 50	24
51 to 100	10
101 to 200	10
201 to 500	10
Division in Which Materials Group Works:	
Staff Function to Management	19
Engineering	81
Production or Manufacturing	4
Divisions or Departments Served by Materials Group:	
Research and Development	77
Engineering and Design	96
Manufacturing and Production	81
Other	35
Date When Materials Group Was Formed:	
Prior to 1940	20
1940–1949	46
1950–1960	34
Functions Performed by Materials Group:	
Evaluate, Select Materials	96
Initiate Materials Changes	73
Advise on and Review Choices of Materials by Others	90
Develop or Modify Materials	77
Develop, Plan, Supervise Testing	88
Solve Materials Problems in Manufacturing	86
Prepare Materials Standards, Specifications	90
Collect, Organize, Disseminate Materials Data	83
Handle Vendor Relations	52
How Materials Groups Are Organized:	
By Types of Materials	69
By Property	15
By Product, Part or Component	8
By Function (R&D, Application, Standards)	8

tions for outside purchase of plastics moldings and castings. In addition to being concerned with the materials that are used in the meters, he selects the packaging materials and is responsible for all processing and maintenance materials used in the plant.

■ Companies in the chemical and process industry are large users of a great variety of materials including plastics, elastomers, high alloy metals, and coatings. Consequently, many of them now have materials groups. The Materials Engineering Section of the General Chemical Div., Allied Chemical Corp., is a typical one.

The section is located in the central engineering department and is composed of eight people. A large share of its work is providing assistance to project engineers and other sections within the engineering department who are concerned with the design of new plants and equipment. Thus, when a project is started, a materials engineer is assigned to it. He reviews corrosion requirements in advance, plans tests to be run if existing data or experience is insufficient, and makes recommendations on materials to be used. He also reviews drawings and bills of materials or specifications, and evaluates the effects of welding and heat treatments on the corrosion resistance of the materials involved.

These three examples briefly show the general nature of materials engineering groups as well as the diversity of their organization and operations. More and more groups such as these are being formed as the value of a centralized materials department becomes apparent to industry. *— H. R. Clauser*

A Critical Look at Materials Research and Development

by William J. Harris, Jr.,
Executive Director,
Materials Advisory Board,
National Academy of Sciences-
National Research Council

In the previous articles we have uncovered the elements of the Materials Age. What has been the impact of this new technological era? As the following articles will show, the impact has been widespread, with repercussions in research, education, technical societies and other areas.

Today, for example, the most pressing programs of research and development are not in mechanical and electronic devices—whether for civilian or military applications—but in the materials that are needed to make these new, sophisticated devices work in strange and hostile environments. Effective materials research and development has become an objective of highest priority in the government.

The author tells why we must have a long range, planned program that is properly balanced—and some of the things we must do to achieve this goal.

The materials community in the United States encompasses Government and private groups representing materials producers and consumers, as well as non-affiliated organizations such as the universities and nonprofit research laboratories. Each of these has a different viewpoint. While this is not surprising, it does make it difficult to arrive at solutions to the very complex and difficult materials problems that we are now facing. A greater degree of harmony between materials producers, users and government sponsors on such critical items as timing of research programs and planning for future needs is necessary in the national interest. Progress is being made but not rapidly enough.

The rate of development of materials used for commercial applications is subject to rigorous controls by economic factors. Materials producers have well-established methods for gaging their markets, and they have research and development programs that are consistent with their economic ability to introduce new materials, processes and products. It is reasonably certain that materials developments for commercial applications are in harmony with overall requirements.

It is in the military field that the shortcomings of materials are becoming more and more evident. The rate of development of materials is not keeping pace with the more rapidly developing concepts of advanced military devices. Available materials do not have the level of properties required to meet some of the needs for high performance and low weight devices, nor to meet the level of quality and uniformity required by the much reduced factor of safety in weapons, space vehicles and nuclear systems.

We Need Long Range, Planned Materials Research

The formidable argument that anticipating materials needs invites economic risk does not change the technical character of the problem or make it any less critical. Unfortunately, the slower processes of materials research and development are all too often not even started at a time when fast-moving programs in design and engineering are well under way.

Thus, the biggest single factor in the administration of materials research is the problem of lead time. From the point of view of those working on materials, it is difficult to understand why so much support is given to the design of equipment for which no suitable materials are yet known. And why intense support of materials research and development comes only when end-item pressure is upon us. Furthermore, materials research and development people wonder why there is so much confidence in the technically hazardous and expensive process of crash research and development, and so little confidence in the thesis that adequate lead time and early initiation of research programs can be less hazardous and cheaper.

Profound changes in the properties required of materials can result from every new concept in the design of equipment. Thus, priorities and emphasis in materials research and development will be in a constant state of flux if these priorities are based on a month-to-month appraisal of current equipment requirements. The national program of materials research and development should embrace a more substantial long range effort. Without such a program, it seems certain that we will have a perpetual state of crisis in materials development.

Recently, large numbers of

new organizations have been encouraged to participate in government materials programs. While the strength of American research and development has resulted from the competitive interaction of many different groups of investigators, we are now paying a very high price for this practice. Greater centralization of *objectives* for materials development, already encouraged by many groups, should continue.

The reason is easy to understand. Defense expenditures to create new materials and to improve old materials are now reaching several hundred million dollars a year. Many of the technical requirements of one defense department are reasonably similar to those of another. Under these circumstances, greater centralization of materials research and development in the Government should increase efficiency. Such centralization will eventually require that the support of research and development on materials be recognized as an end-objective in its own right.

The trend is gradually being reflected in the agencies most concerned by deficiencies in available materials.

For example:

1. The Army, the Navy, and the Air Force have recently taken steps to increase the degree of centralized responsibility for their own materials programs.

2. The Office of the Secretary of Defense has created the position of a Special Assistant to the Director of Defense-Research and Engineering, who is concerned primarily with materials.

3. The Federal Council on Science and Technology has created an ad hoc committee on materials.

These steps are leading to more effective programming of materials research and development at the national level. They recognize the role of the Government in its support of research and development on materials science, its support of work and facilities relevant to materials development, and its support of that increased degree of communication between designers and the materials community so essential to proper scheduling of development programs on materials.

This need for greater centralization of responsibility does not mean that we should create one central administrative group to control all contracts and supervise all research and development. Even if such a central authority were created, it is quite evident that the individual departments would still have to be responsible for assuring availability of materials for their own vehicle and component programs. Nevertheless, creating a central point of focus for materials research and development is worthy of the most careful consideration.

We Must Have Balanced Materials Research Program

Great care must be taken not to move too rapidly in all directions in developing an adequate materials research program to meet our military needs. A proper balance must be established between three quite distinct aspects of materials research: materials science, materials development and materials application.

A materials science program is basic—There must be an adequate research program on the physics and chemistry of solid and liquid state materials. In the field of electronics, contributions of solid state studies to the basic science and processing of materials have been exceedingly valuable. In the field of strength of materials, studies of a fundamental nature have been very helpful in developing concepts that are beginning to be applied to the improvement of actual engineering materials.

At least a ten-year period of concern with fundamentals is necessary before the first inkling of their application is likely to emerge. Accordingly, a substantial program supporting brilliant individuals doing work of a fundamental nature (with the program completely under control of the investigator) is essential.

It is clear that neglect of the study of science will ultimately result in technical stagnation. Creation of the necessary environment or social climate in which scientific accomplishments are likely to be produced has been largely the province of the universities. There is real fear today that continued short-term financing of research and contracting on a project basis are deterrents to effective use of competent people in the universities. On the positive side, the current development of a series of materials science programs in universities under government support with a completely different approach toward financing is a very encouraging sign of the recognition of the importance of the right environment.

Elsewhere, a few large corpo-

rations are finding it possible to organize science-oriented programs, and it is likewise true that a few government laboratories exist in which there have been effective fundamental programs. Nevertheless, in both industry and government it is exceptional to find administrators willing to give the scientists that sense of freedom from administration which is necessary for them to work over a long period in a productive manner.

The great opportunity of a democratic system of government should be the creation of those circumstances under which individuals are free to attain their highest potential. Thus, continuing care must be taken in administration to make certain we do not over-organize and prevent individual talent from making its greatest contribution.

Materials Development Must Start Earlier, Have More Support

An adequate program—larger than the present one—must be organized to promote the orderly development of promising materials now in the laboratory stage. This is vital. Until the last decade materials development was exclusively an industrial responsibility. However, it has become increasingly apparent that the very limited government market makes it difficult for industry to recover its cost through the normal route of profits made by selling a product. Many development costs, including the cost of new processing equipment and special facilities, exceed an industry's ability to pay when it is faced by a very limited defense market. Accordingly, the rate of development of new materials is not likely to be fast enough if determined by conventional economic standards.

The government has played an important role in developing some materials. Titanium is a good example and one that illustrates the problem of lead time. Laboratory samples of titanium with a strength of 180,000 psi at room temperature were available in 1949. However, these high strength alloys did not become available in proved mill products until 1957, and they were not available for delivery to procurement specifications until somewhat later. This ten-year period may appear extreme but it is probably typical of the time lag to be expected in the development of complex new materials with special properties.

The problem of cutting research and development lead time has been studied by every organization responsible for the development of new materials. The problem is particularly difficult to resolve with defense materials. Separate facilities for producing defense materials cannot be justified when only small production runs are required. On this basis, a special defense material may have to be made with equipment geared for large scale commercial production. And the processing personnel may not be accustomed to the high quality, low production practice essential for a special defense material. All of these factors contribute to greater lead time and they cannot be resolved easily by any change in administration or organization procedure.

Serious consideration must be given to direct support for defense materials industries. Such support was once provided through government facilities; the best solution at present may involve outside contracts and facilities.

Uncertainty about future can harm incentive—As the materials needs of military programs have drawn ahead of the civilian market needs, there has been less incentive for organizations to commit their best efforts to defense projects. In the aircraft and astronautics industry, some companies that have been created are more than 95% supported by government contracts. Here successful competition on preliminary studies keeps a prospective contractor in the running and very often assures him a high priority of goods for a production contract.

However, in the materials field an organization's successful prosecution of research and development projects often does not have a direct bearing on its success in getting orders for products. Also the incentive in terms of a new market created by successful materials research and development can often be very small. Thus, the whole question of incentives for the materials contractor in materials research and development should be re-analyzed at the present time.

Materials Producers Must Understand Defense Needs

All too often we have found that insufficient understanding of defense materials problems prevents materials producers from guiding their programs in an intelligent manner. As a result, screening of materials is not adequate and the most effective use is not made of

available manpower and facilities.

For example, the government has given much support to four producers of titanium mill products. However, the market has failed to develop as rapidly as predicted and only one of them is now solely concerned with titanium, although the other three are still factors in its production.

Similarly, up to 20 organizations are now interested in one or more of the refractory metals from the standpoint of producing raw materials or mill products. At this time it appears that there is not a sufficient market in sight to utilize the productive capacity of more than two or three prospective producers. Unless the greatest care is taken in placing research contracts with just a few companies it is quite likely that the supporting research program will be diffuse and far less effective in providing the user with the material he needs. Administratively, it would not be easy to select and sponsor a few producers. Economically, it could offer striking advantages.

Materials Education, Process Experience Vital

As is made clear elsewhere in this issue, there is a ferment in materials educational programs today. Old lines of demarcation between classical disciplines are breaking down. This change should be encouraged in order that the next generation of materials scientists and engineers have a greater potential for recognizing critical problems and for being directly responsive to them. We must be certain that materials science, materials development, and their interrelationship in application, are stressed.

Processing and fabricating experience is also important. Very often the utilization of a new materials concept is limited by deficiencies in processing methods. For example, the greater understanding of the importance of interstitial elements and lattice defects on behavior of materials that we are gaining cannot be used to advantage until better processing techniques are available.

Likewise, many interesting materials that have been developed as mill products have not found extensive use because of limited fabrication processes. Current problems in joining high strength titanium, high strength steel sheets, and refractory metals are a good example. Also, the very promising ceramic and graphite materials are limited because of deficiencies in processing techniques that affect uniformity and performance.

Cooperation Needed to Anticipate Design Needs

Engineering requirements for materials are often very confusing to the materials investigator. They change rapidly, they are expressed in terms that are not always familiar, and they very often are not presented at all until a design is complete and new materials of a very special character are specified for use at a very early date.

Another problem is that most individuals concerned with the development of materials have had no engineering design experience. Those who have are not likely to be familiar with the new environments associated with space, re-entry, nuclear propulsion, etc. Accordingly, they are not in position to analyze for themselves the probable technical requirements of materials for future systems, nor even to ask the right questions of designers who are in the conceptual design stage of creating a new component.

Thus, the problem of communicating materials requirements and interpreting them correctly emerges as critical. Unless materials developers can anticipate design needs before designs are actually created in detail, they will continue to be in the position of organizing crash programs to meet specific new situations.

Much trouble can be saved in coming years if we are certain that we understand the real nature of a stated requirement before we start extensive materials development programs. Everyone concerned with materials can recall examples of the misuse of materials by designers, as well as examples of programs carried forward aggressively and then abandoned because the first statement of requirements proved erroneous.

It is clear that the problem of technical communication between designers and materials developers must receive much more attention in the future than it has in the past, particularly with respect to defense programs.

Re-entry and space—Until he has a greater understanding of the new environments in which materials must operate, the materials developer is likely to continue to be confused by apparent sudden changes in requirements. This situation is

typified by one of the crises in materials in the 1950's associated with the design of re-entry vehicles. The typical ways of expressing the characteristics required of nose cone materials assumed equilibrium conditions. By this assumption, it could readily be shown that temperatures at or exceeding the melting point of any known material were to be expected. Aggressive materials studies were initiated but the problem was not resolved by this approach.

Concurrently, a critical appraisal by aerodynamicists and thermodynamicists of the thermal environment during re-entry led to the conclusion that transient heating was the design condition. Calculations of the magnitude of the heat pulse were verified by experimentation, and means of simulating the heat pulse were developed. With test methods in hand, it was possible to screen many promising materials and to utilize existing materials for the solution of the problem.

A similar problem today is the space environment. At this point we do not understand the properties that are required of materials well enough to guide development programs, nor can we set objectives that are likely to be valid for development programs. From a materials point of view, there must be an intensive program aimed at clarifying all aspects of the space environment that could affect the behavior and performance of materials. With such a program, it is likely that procedures for testing and screening materials could be established that would eliminate much of the need for new materials research and development.

What R&D Directors Think About Materials Research Today

The author of the foregoing article is of course concerned primarily with the national defense. How do the producers and users of materials for industrial and consumer products feel about the status of materials research and development today?

To find out, the editors surveyed research directors representing a broad cross section of American industry. As expected, the survey turned up a variety of opinions on such questions as the role of the government in research, the proper balance of projects among the different types of materials, and the manner in which materials research and development should be financed. It is clear that the long range solutions to these problems will be compromise solutions that will not be satisfactory to all concerned.

Here are the questions we asked and the answers we got.

Is government sponsoring too much or too little research?

Any opinions on this question depend a great deal on how well you are informed on government research projects, and whether or not you believe that the government should become involved in research in the first place. Thus, such a question is bound to elicit a wide variation of opinion. The replies show that research and development directors can be roughly divided into three categories: those who believe that government is spending 1) too

much, 2) an adequate amount, and 3) not enough.

In light of recent publicity it is not surprising that a few R&D directors have some sharp comments to make about the duplication and overlap of government research and development programs. Two directors say that materials research is:

- "Adequate at this time but could be improved by coordination of overall effort."
- "Poorly organized and there is much duplication of effort. Research effectiveness is 50% and even though the dollar level is OK we could get more for dollars spent."

Another serious problem, according to the manager of research for an important steel company, is "duplication of effort due to industry security measures.

"I have no ready answer for this problem," he says, "but it does seem a waste of time and money from the national security angle.

"Another restriction is the requirement that you have a government contract before you can be cleared to obtain government reports; yet the Air Force claims it is trying to get industry to do more research without support."

Another man, representing a major independent research company, puts the finger on the management of research itself: "It is the management of research and development that causes the apparent waste and overlapping of activity we hear so much about," he says. "Effective utilization of manpower and application of research data are the two greatest areas for realizing additional values and returns from expenditures."

Who should perform government sponsored R&D?

Although many respondents feel that all three groups—industry, the military and the universities—should perform government sponsored research, there is a slight majority that feels that the military itself should not perform any materials research, i.e., that such research should be performed by industry alone, or allocated in varying proportions to industry and universities.

Several directors voiced the opinion that the universities should confine their attention to basic research and that industry should stick to applied research. In the words of one:

"Industry should perform the bulk of research; universities should be given an opportunity to do a certain amount of basic research; and the military should do research only when it is impossible to get it done by industry."

In the same vein, the associate director of research of one of our largest companies says that "more *industrially financed* materials research should be encouraged by the government." As an incentive to spend private money, he suggests that "the government give tax relief to companies who are willing to spend their own money on critical materials research, similar to the fast amortization write-off granted to companies who build (or have built) plants and set up production facilities for critical materials or products."

This approach, he believes, "would cut down the expense for government contracts, would preserve the patent structure of a company, and would bring able scientific teams into materials research who would otherwise shy away from government contracts."

Should government sponsor more materials research directed toward commercial applications?

The research directors contacted were almost unanimous in declaring that the government should "stay out of commercial applications."

In a free economy, they believe, research on commercial materials "plainly does not belong in government hands" and can be most effectively performed under the pressure of inter-company competition.

Are any materials being investigated too heavily today?

It is extremely difficult to keep informed on the many materials research programs now in progress. This much was clear when about half of the research directors replying to this question frankly admitted that they just did not have any opinion on the question.

Of the remaining directors most felt very definitely that we were not overemphasizing any materials in our research program.

However, several R&D directors believe that research on metals – notably titanium and refractory metals—may be stressed too heavily today. Two comments:

- There is "wasteful work on exotic refractory materials and overlapping research activities in certain of the newer metal applications."

■ "There are waves of 'fashionable research' which, unfortunately, lead to insufficient research on older materials . . . the overall material research for the country as a whole is highly unbalanced at all times."

Typifying the uncertainties of research is one man's comment on what he referred to as the "terrific emphasis" on refractory metals:

"Who can say if it is too much —maybe it isn't enough."

Conversely, are we ignoring any important materials in our research?

On this question roughly one-third of the respondents felt quite strongly that many materials, notably nonmetallics and high temperature materials, were definitely being overlooked. Some of the comments, however, again indicate a lack of information on current research.

Many R&D directors believe that much more work is needed on nonmetallics. In particular, they call for more work on 1) high temperature plastics, 2) the fundamental properties of plastics and nonmetallics, and 3) composite materials, especially reinforced plastics and metals.

A few respondents cited the need for more research on ceramic materials for structural use in high temperature engines, missiles and reactors.

One of these men, research director for a leading ceramics company, said he was "convinced that a very substantial government-financed research program on the fundamentals of ceramics is essential if solutions are to be obtained to the many pressing material problems confronting missile and aircraft designers.

"I am actually thinking of a multi-million dollar research institution, probably government owned but operated by a leading university or technological institution, in which a large corps of research personnel can be put to solution of the problems inherent in using ceramics as materials for mechanical devices," he said. "I do not believe that sufficient effort is being devoted to this very important problem of making ceramics into respectable engineering materials. Nor do I believe that private industry can or will spend the money necessary to make the breakthroughs in this area. The problems are so difficult, and the studies so expensive, that this seems to me to be appropriate as a massive government effort."

He believes there is a great disparity between the amount of government money applied to ceramic research and that which has been and is being spent for research on metals, especially high temperature metals.

"At a guess, I would say that the effort on metals is 50 times that on ceramics."

He is frank about his company's proprietary interest in a government program.

"Government money, spent through prime contracts, is gradually building up in the hands of private contractors enough ceramic knowledge to tempt them to go into the production of ceramic components in competition with commercial industry."

The need for more research on the fabrication of materials has also been strongly stated.

"Our weakest link is how materials can be worked, formed and joined—particularly the higher temperature metals, ceramics and cermets," one man says. He believes this area needs new ideas, breakthroughs, and a really big effort requiring the funds of government.

"Present and costly materials studies are wasting money with obsolete processes," he claims.

Should there be less product-oriented research and more basic research on materials?

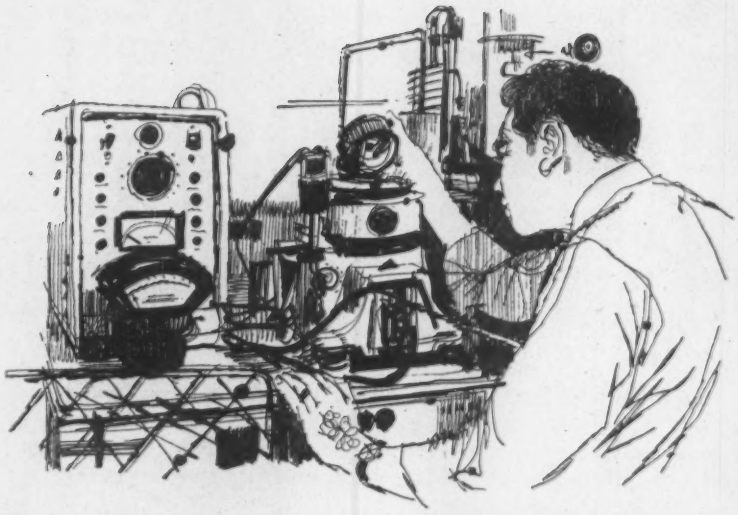
This question, or these two questions, have produced quite a lot of soul-searching among research people in recent years. There appears to be quite a difference of opinion on product-oriented materials research. Most research directors evidently feel that we are performing too much of this kind of research; however, a sizable number seem to feel that we are doing enough.

As expected, there is almost unanimous agreement that there is a definite need for more basic materials research. There were few dissenters on this point, suggesting an increasing awareness of the advanced state of Russian technology and the dangers it poses to this country.

Who should bear the expense of basic materials research?

Replies to this question clearly indicate that if there is to be any long range planning, the plans are bound to be unpopular with some of those affected.

If any conclusion can be drawn



it is that a good proportion of research directors believe that materials research should be financially supported by both industry and government. The proportion of expense that each has to bear is a point of contention.

"If a large market is assured then industry can afford to take the risk," one director says. "But where the market is highly uncertain, limited quantities are required, etc., then government should pay."

Two opinions that indicate the range of reaction:

■ "The government should sponsor certain basic research, but industry should carry its portion of the costs, particularly when the research is directed toward specific commercial products."

■ "Government support should be in the form of support to university laboratories, with only very general direction of research indicating areas of interest."

Many research directors apparently believe that the expense of basic materials research should be borne by those who expect to benefit from it. What seems at first glance to be a sound, practical approach is, however, complicated by the fact that, as history shows, no one can predict how basic research will pay off and who will ultimately benefit from it.

Is materials research being restricted by manpower shortages. If so, what kind of specialists do we need?

Although most research directors believe that present manpower is adequate, many are strongly disturbed about the caliber of the people doing the work.

"Superior scientists and technologists are in short supply; there are plenty of average men," is the way one director puts it.

Another: "We aren't as short of manpower as we are of imaginative people with imaginative supervision."

It is also evident that many directors believe many of their problems are caused not by lack of manpower but by misuse of personnel.

"We are plagued," says one, "not by a manpower shortage, but by an appalling waste of manpower, primarily due to poor planning. I would guess that the overall efficiency of our technical manpower is less than 20%."

He concluded: "We do not need more specialists; we need more maturity and common sense at all levels."

On the other hand, many research directors do feel that definite manpower shortages exist in certain areas. Of those concerned with such shortages many felt that we could use more physicists. Need was also expressed for more metallurgists, chemists and ceramists.

Are materials producers doing enough materials research?

In recent years much publicity has been given to the expanding research of the materials suppliers. Consequently, it is surprising to learn that most (but not all) research directors believe that the materials producers are still not doing enough research. Just how much materials producers can spend on research before they are financially in trouble, of course, is debatable.

Are users of materials doing too much research and encroaching in areas best left to the materials producers?

No, say most research directors. Although many people have expressed concern over the need for large aircraft, electrical and manufacturing companies to do much of their own materials development rather than relying on materials suppliers, the majority of respondents say there is no choice at present.

As one man put it: Materials users have to perform research "because materials producers do not always see far enough ahead or cannot see the profit picture in specialized applications." — *R. J. Fabian*

The Two Major Trends in Materials Education

by Lawrence H. Van Vlack,
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Basic to all future activities in the research, development and engineering use of materials is the materials education provided by the universities. The two new disciplines of the Materials Age —materials science and materials engineering—are beginning to be reflected in curriculum changes. In most schools, the ordinary descriptive approach to materials courses is being abandoned in favor of a more fundamental approach. In addition, a few engineering colleges now offer degree programs or options in materials engineering.

These trends are discussed by a professor who supervises what is at present the country's only undergraduate degree program in materials engineering.

Today's design engineer is faced with the continued necessity for reducing cost and for meeting increasingly severe service requirements. He must examine whether he is utilizing materials most advantageously in current applications and whether materials will be available for the advanced engineering designs of tomorrow.

At the same time the engineering educator must ask two corollary questions: Are future engineers being trained so that they will be able to select the best available materials to meet the necessary service specifications? Are materials specialists being trained who can develop the new materials required by tomorrow's design engineers?

The engineers in the teaching profession do not claim to know the final answer. Fortunately, however, they are giving considerable thought and effort to these questions. From these efforts two new patterns of teaching are appearing in our engineering colleges that should be of interest to those engineers who are concerned with the materials aspect of design:

- One new pattern is a change in the way materials instruction is given to those students who are associated with electrical, mechanical, structural, chemical or related engineering curricula.
- The second new pattern is the emergence of the materials specialist, i.e., the Materials Engineer, as a new area of technical training.

Trend No. 1— More Instruction on Materials for the Engineering Student

The old approach: descriptive courses—The student who has not encountered a course in materials before he enters an engineering design course must depend entirely on tabulated data for the property values he chooses. Such a student is generally limited in his choice to those materials which had been used previously, or to those materials which are suggested by others. This student (and eventual engineer) usually is quite unaware that the properties of materials may be changed by various production

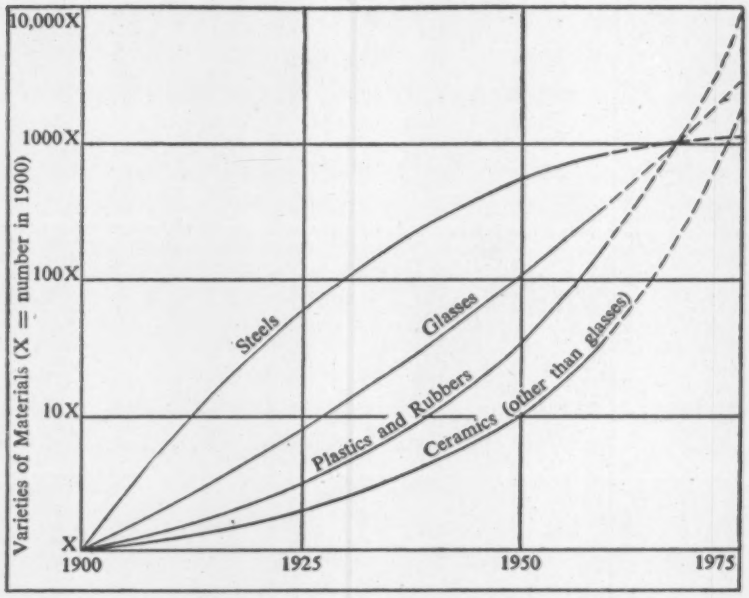
treatments or by service environments. Obviously he has to incorporate major safety factors into his designs.

Some years ago it became evident that a student, and an engineer, could produce more effective designs if he had been familiarized with various materials. The Civil Engineers led by offering courses in "Materials of Construction." The Mechanical Engineers, who make extensive use of metals, offer their students a course in Metallurgy. Similarly some Chemical Engineers receive a course in Corrosion. In general, each of these courses involves a systematic consideration of various types of available materials, their properties, and occasionally their limitations. Thus a student is given the advantage of becoming familiar with some of the materials that are currently available in his area of initial specialization before he must attempt to select materials for his engineering designs.

The inclusion of these courses in the curricula has not completely solved the materials problem for the future engineer. The problem is complicated in two major ways:

1. The chief complication is the fact that the number of available materials is growing at an ever accelerating rate (see Fig 1). The student cannot begin to be exposed to all the materials that are currently available. Even if he were to become familiar with the multitude of currently available materials, before he was halfway through his engineering career he would encounter a still larger number of even newer, more radically different materials.

Fig 1 *Increase in varieties of engineering materials since 1900 is likely to continue.*



2. A second complication is the fact that a large proportion of engineers are eventually concerned with designs outside the area of their initial specialization. You need only look at the background of many of your associates in the design field to appreciate this as a fact. Should the mechanical engineering curriculum, for example, be expanded to include electrical materials, corrosion resistant materials, nuclear materials, etc., in addition to materials for mechanical design?

Clearly the problem of materials instruction is still before us.

The newer approach: materials science—The engineer must draw upon basic principles. The design engineer is well aware that he cannot determine the stresses in a pressure vessel, a rotating shaft, or a column without a knowledge of the principles that govern the nature of those stresses. The science of engineering mechanics is required to predict the distribution of stresses. Likewise the design of a digital computer, a video camera or a transformer requires a knowledge of the principles that govern electrical circuitry. The electrical sciences are used to predict the behavior of the required circuits.

Until recently the engineer has not had principles that permitted him to anticipate the behavior of materials. Previously each material had to be considered individually. Materials that had not been studied could not be compared or contrasted with other, better known materials.

Now a science of materials is emerging which can provide this knowledge of the principles that govern the properties and behavior of materials. Although this science has been pursued on an advanced

specialized level as Solid-State Physics, it was only about four years ago that the more elementary aspects of this science were introduced into undergraduate levels at a few engineering colleges.

The University of Michigan and the University of California (Berkeley) led by paying particular attention to the dependence of properties upon the material's internal structure and the material's service environment. Almost concurrently, the American Society for Engineering Education began studies directed toward the same end as a follow-up to earlier proposals concerning the engineering sciences.

The principles that may be formulated within a materials science give the engineer a basis for understanding the nature and behavior of a wide variety of materials. With such a background the student has the potential to anticipate the properties of materials that have not been studied, or, for that matter, materials that are as yet undeveloped.

As shown in Fig 2, the properties of materials may be related directly to the structures found within the materials. Proceeding from atomistic to macroscopic structure:

1. At the finer end of the scale the nature of the bond between atoms may be correlated with properties such as melting temperature, strength, abrasiveness, electrical conductivity and thermal conductivity.

2. The arrangement of the atoms within the material — crystalline, molecular or amorphous — markedly influences ductility, toughness, strength, dielectric properties and surface properties.

3. A material with a microstructure containing two or more phases has properties that depend upon the distribution, size and character of the individual phases. We utilize these variations in adjusting properties of steels, of plastics—of a large variety of other materials, both metallic and nonmetallic.

4. Finally the properties of materials depend upon gross structures such as porosity, surface area, sur-

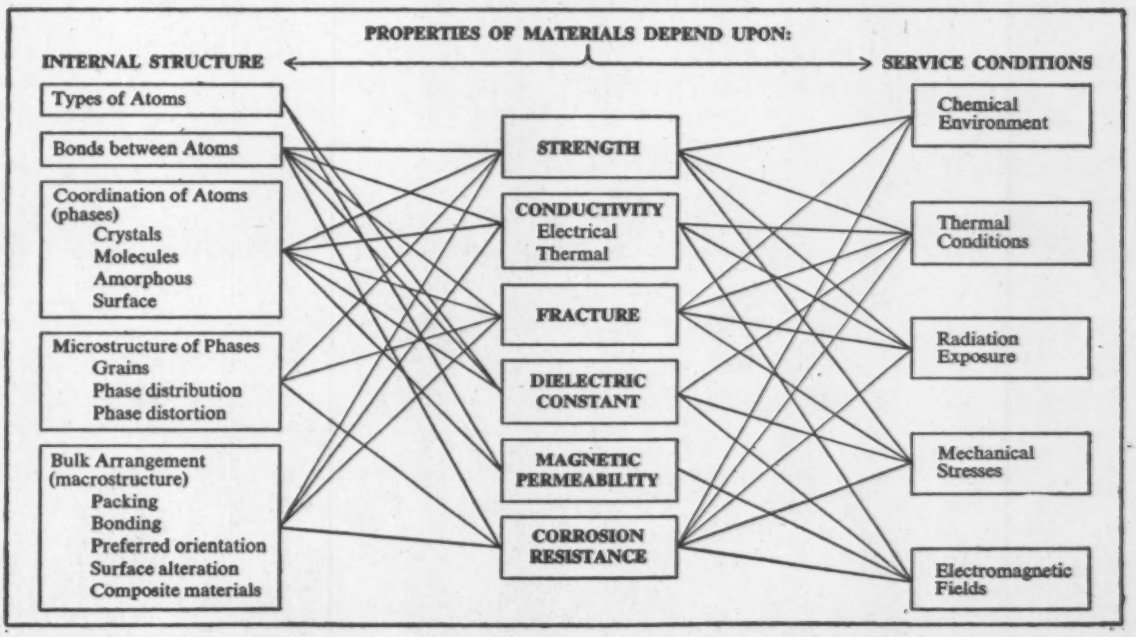


Fig 2 *Properties of materials are related to internal structure and to service conditions.*

face alteration, and preferred orientation.

Properties are also influenced by the service environment which the material encounters in its eventual application. These environments are conveniently divided into chemical, thermal, radioactive, mechanical and electromagnetic.

Materials courses incorporate science of materials — The present trend is toward courses that incorporate the science of materials to a greater extent. They offer engineers three important advantages:

1. The increasing multitude of materials do not have to be considered individually.

2. New materials may be considered more critically for current design.

3. New service requirements may be evaluated in terms of currently available materials as well as future materials.

Each of these advantages increases the design engineer's effectiveness. At the same time we cannot claim that the science of materials is fully developed. In fact, it is very apparent to all materials specialists that this approach is only in its beginning stages.

Trend No. 2—More Materials Engineers

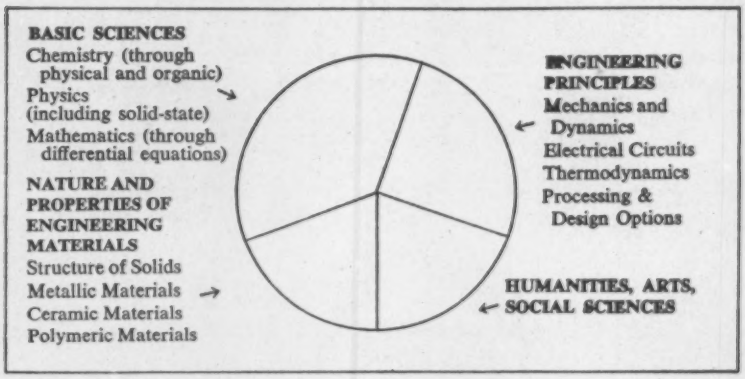
Why we need better materials engineers—A Materials Engineer is a specialist who is concerned with 1) the development of new materials, and 2) the critical application of materials in engineering design.

He must understand the basic nature of materials so that he can develop real materials from the chemist's and physicist's ideas. And he must understand the end uses that prescribe the design requirements. To this end, he must be conversant with the mechanical, electrical, structural and chemical engineer.

We have had "Materials Engineers" for some time. These have included metallurgists, ceramists, organic chemists, mechanical engineers, civil engineers, and other related specialists. Note that this list includes two main categories of engineering specialists: 1) those who are concerned with specific materials, and 2) those who are concerned with specific end applications.

Modern industry does not divide its design problems along the above lines. Industry wants to use the best material whether it be a metallic, plastic or ceramic material. The materials used by industry must simultaneously meet thermal, electrical, mechanical, structural and other requirements. Therefore, materials development and specification cannot be limited to a particular technical discipline.

Fig 3 *Materials engineering program at University of Michigan stresses basic sciences.*



Materials curricula have emerged—Educational programs that emphasize materials development and specifications are relatively new. The first one was developed in 1952 at the University of Michigan. Since that date the Michigan program has undergone additional evolution. Its present form is indicated in Fig 3. Note the following features:

1. A basic background of chemistry and physics is required so that the Materials Engineer may have a basic understanding of the solid-state principles that govern the properties of materials.

2. Specific attention is given to metals, ceramics and polymers.

3. The student has the option of directing his attention toward the processing of materials or toward the application of materials.

Advanced curricula leading toward master's and doctoral degrees are also available. In general, these are more flexible and may be directed towards individual student interests.

Other schools are also emphasizing materials engineering. It is

quite logical that a materials engineering curriculum within any individual school should be an outgrowth of that school's particular educational setup. In some schools, materials engineering receives attention as an option in mechanical, electrical or chemical engineering. Other schools with strong metallurgy or ceramic curricula are making an effort to expand these curricula to include metals, ceramics *and* plastics. A third procedure is to expand the engineering mechanics curriculum to include: 1) thermal, electrical, and chemical behavior, in addition to mechanical behavior, and 2) the non-isotropic characteristics encountered in nearly all real materials. A fourth procedure in many large schools is to expand graduate and research programs into areas of materials science.

The growing challenge: design of materials—The biggest challenge to the Materials Engineer is the possibility of designing a material for a specific application. This has already been done for some applications. The transistor depended upon the development of an appropriate semiconductor. Boron nitride and artificial diamond are direct outgrowths of materials science. Ausformed steels were developed in response to the demand for ultra-high strength metals.

Despite these outstanding examples, the procedure is in its infancy. The Materials Engineer of today and tomorrow has innumerable opportunities to provide new tailor-made materials. Properly equipped he can make unique contributions in the broad new field of materials research that lies ahead.

Education of the Materials Engineer

The previous article represents the thinking of a leading university which has already graduated a few materials engineers. To what extent is it shared by other universities?

There is ample evidence that the educators in our universities are fully aware of America's need for scientists and engineers trained in the broad field of materials. But how much of this need should be answered by college courses? What is being done now? What is the outlook for the future?

Here are the conclusions we have drawn on the basis of personal interviews conducted at leading engineering colleges.

Without doubt, there are as many answers to the above questions as there are universities. Almost as many, in fact, as there are engineering professors. But the differences in the answers lie in the deeper areas of course content, level of approach, curriculum, and intensity of enthusiasm. There is no disagreement that science and engineering graduates should have more knowledge of materials structure and materials behavior than they have had in the past. Nor is there any doubt that there is an increasing trend on the part of engineering schools to accomplish this aim.

With the increased trend to interdisciplinary cooperation, nearly all universities have some form of interdepartmental committee or parliament which investigates, or even initiates, proposed curricula changes. It is in the hands of such

committees that the educational fate of the materials specialist lies. But behind the scene there is usually one interested group which is actively planning and pushing for broader materials education.

Who Is Pushing for Materials Education?

There is no one answer. It depends on the university, on the interests and experiences of the department heads and professors, and—it must not be forgotten—on the nature and size of the student enrollment.

One thing is certain. Metallurgical departments in almost all universities see the need for broadening their subject matter to include a wider range of materials. In most schools it is out of the metallurgical department that materials courses are growing, i.e., courses that will be required of metallurgical, mechanical and civil engineers, and, in some cases, electrical and chemical engineers. Even if the course is to be restricted to their own department, professors of metallurgy are in the process of branching out to include—in at least a one-semester course—ceramics and polymers.

Other springboards of action may be the mechanical engineering department, the physics department, the applied mechanics department, the civil engineering department—or, perhaps, the dean of the engineering school. Chemical engineering departments seem to be more aloof in their attitude, although at one school—Rensselaer Polytechnic—*all* departments, particularly chemical engineering, are actively interested in pushing for increased materials education.

Electrical engineering, too, stands somewhat apart. Not that professors in this field do not recognize a need for materials knowledge. But the major demands of this branch of engineering are more specialized, calling for solid-state physics theory and a concentrated knowledge of electrical and magnetic materials behavior. Usually when a general materials science course is set up within a school, it is modified for the electrical students. Some critics in other disciplines, however, feel that educators in the electrical engineering field are apt to be short-sighted with respect to structural strength problems of materials. They point out that the majority of failures of electrical equipment are due to thermal or mechanical stresses on materials.

Why Not Just Go Ahead?

It would seem that if most universities, deans and professors agree on the need for trained materials specialists, there is nothing to argue about. Why don't they immediately institute degree programs in the field? Or at least immediately introduce a one-semester or one-year course in engineering materials for all science and engineering students, regardless of their specialization?

Here are some of the major reasons:

1. It takes time—Interdisciplinary cooperation, if obtained, still results in varied and lengthy proposals, discussions and unresolved conflicts. Professors, contrary to popular opinion, have extremely heavy work schedules, and such planning as is necessary to revise curricula and introduce new programs of study is very time-consuming if done right. And it will be done right, or not at all, for there is probably no other professional group as self-critical as engineering educators.

2. Many different approaches are possible—The study of materials science and engineering can be approached in various ways. We may roughly categorize three basic approaches:

a. The descriptive approach, which discusses particular materials and classes of materials in terms of properties.

b. The solid-state physics approach, which leads from a study of atomic bonding and microstructure to an understanding of gross properties and behavior.

c. The solid-state mechanics approach, which traditionally considers the reaction of materials to external stresses and strains but which can be modified to use a study of crystal aggregates and macrostructure to predict materials behavior in specified environments.

Each of these concepts, particularly microstructure and macrostructure theory, will be included in any complete materials study; the fundamental difference between curricula will be where the student begins and how he uses the three approaches to build up a logical and useful picture of materials behavior.

There is no single textbook which is considered satisfactory, although Prof. Lawrence Van Vlack's *Elements of Materials Science* is believed to be the best available at the present time. Prof. Van Vlack, however, is a metallurgist, and metallurgical thinking today is oriented

toward microstructure theory, tending toward solid-state physics. Others, such as Prof. Joseph Marin of Pennsylvania State University, feel strongly that microstructure theory is too difficult and too far out of context to be presented in sufficient depth to the average general engineering student.

Some other texts being written at present include one by Prof. Marin which uses a solid-state mechanics approach, and one by Professors Hobstetter and Madden of the University of Pennsylvania which uses essentially a solid-state physics approach.

Even where the basic approach is agreed upon, there can be many opinions on the proper sequence of topics and on which should have the major emphasis. One fundamental problem will always be whether to put the emphasis on depth of study or on broad coverage. There is no intention here to cover in detail the fundamentals or merits of each approach, but merely to recognize the problem as one each university must solve for itself.

3. Many practical problems have to be solved—Theories of education aside, major changes in curricula raise many ordinary problems having to do with personnel, space, equipment, and the simple mathematics of graduation credits. Specifically:

a. *Who will teach?* Few professors are qualified to teach all aspects of a broad course in materials. One solution is to use several professors from different departments to teach various segments of the same course. This, however, presents several difficulties. It creates a problem in the scheduling of classes and the equalizing of the teacher's workload over the year. It can also result in poor response from the students.

Establishment of a degree program can create correspondingly greater problems. It usually means the teaching staff must be increased; perhaps that a new chair be established—preferably, of course, endowed.

b. *Where are the facilities?* Laboratory work is usually considered a vital supplement to lectures. Such work may easily be beyond the capabilities of present space and equipment.

c. *Which course to drop?* If a materials course is to be required, each discipline will generally find it necessary to drop or shorten an existing course. There are not many elective choices for the engineering student as it is, and it is not thought wise to replace electives with additional required courses.

Each department must therefore revise its curriculum. Along with this consideration, remember that there are dozens of other courses, in addition to materials courses, that each discipline feels should be included in the undergraduate curriculum. Adding a materials course may not, by any means, have top priority.

What About a Descriptive Course?

Since the materials textbooks now used or being prepared seem to emphasize the physics and mechanics approaches, it is reasonable to inquire as to the current status of the descriptive approach—perhaps the most obvious approach to engineering materials, or anything else for that matter.

The word "descriptive" means different things to different people. To most engineering educators, the word refers to a type of course widely given until perhaps ten years ago. This course was pretty much limited to metals; in fact principally to iron and steel. The content included descriptions and diagrams of open hearths and mill operations. Almost all schools have abandoned such courses.

Another type of materials course which has been an old standard, though not strictly descriptive, is "Strength of Materials." It is a laboratory course, often accompanied by lectures on tensile and compressive strengths of materials, which greatly oversimplifies the problems of stress and strain relationships. Although some schools have modified or replaced this course, it is a Civil Engineering course presented to other disciplines and many C.E. professors seem to be somewhat slower to modify their attitudes than those in other disciplines.

By "descriptive" materials courses, we do not refer in this article to these abandoned or modified courses, but to a study which names, classifies and compares engineering materials in terms of physical and mechanical properties, applications and general advantages and limitations.

While most educators (there are some who dissent, though they are not the ones closest to industry's problems) agree that industry has need of engineers and scientists

Interdisciplinary Committees: Machinery for Change

Science and engineering schools now derive a substantial portion of their income from research programs sponsored by industry and government. Such programs not only have the direct end result of adding to our nation's scientific and technological knowledge and know-how; they also provide an incentive and a challenge to professors and graduate students.

Out of this challenge has come increased recognition of the need for cooperation between the various schools and departments of the university. We find chemical engineers, physicists, metallurgists, ceramicists, mechanical engineers, etc., working together, calling upon one another for aid in developing facilities and in completing research programs. This leads to what the universities refer to as interdisciplinary *programs and institutes. It also leads to the establishment of interdisciplinary curricula.*

The study of engineering materials is one field that requires this kind of interdisciplinary cooperation. Whether the planning involves a one-semester or one-year course, or a full degree program, all departments of an engineering school are affected.

Obtaining such cooperation within a given school can be difficult. There are many precedents and personalities involved, as well as many attitudes and approaches which are each valid. But where such cooperation might have been impossible—or at best, unlikely—a decade or two ago, it is now a major trend in the thinking of leading educators.

with some such knowledge, there is not one in favor of even one semester devoted to such study. Unanimously they agree that it is the function of industry to provide such training, or, at least, to provide the incentive for the engineer to acquire such knowledge by his own efforts.

Here are some of the reasons consistently stated:

1. The basic function of our universities is to increase the intellectual power—not the fund of knowledge—of the students. In the case of engineers this aim is intensely practical, since the needs of industry channel engineering graduates into a wide variety of specializations.

2. There is little enough time to teach difficult theory without taking time to present the student with straightforward knowledge which he can easily acquire from textbooks, handbooks, trade magazines and actual practice in industry.

3. There would be a 10 to 15-year lag before the student made practical contributions based on his knowledge. It would then be out of date. Such a time lag may seem astonishing but it is the accumulation of several smaller time lags: **a)** one to three years between discovery and publication of scientific and engineering information, **b)** perhaps two to four years before the professor brings his own knowledge up to date and incorporates it into his course, **c)** three years before the student graduates, and **d)** four or five years before the graduate is in a position to make real contributions to the art.

What, Then, Is Being Done?

Materials education programs are, in the last analysis, only a part of a larger trend toward conservative—never radical—revision of the approach to science and engineering education. One aspect of this trend is the increased emphasis on basic

FRESHMAN YEAR
Same for All Engineering Students

SOPHOMORE YEAR
Same for All Engineering Mechanics Students

JUNIOR YEAR

FALL

Fluid Mechanics	3
Mechanical Properties of Engineering Materials	3
Advanced Strength of Materials	3
Metallurgy Elective	3
Nontechnical Elective	3
Technical Elective*	3
	18

SPRING

Principles of Economics	3
Electrical Engineering	3
Electrical Engineering Laboratory	1
Elements of Vibration	3
Engineering Thermodynamics	3
Industrial Engineering Elective	3
Technical Elective*	3
	19

SENIOR YEAR

FALL

Engineering Lecture	0
Elasticity and Engineering Applications	3
Engineering Mechanics Elective	3
American Economic History	3
Nontechnical Elective	3
Technical Electives*	6
	18

SPRING

Engineering Lecture	0
Applied and Experimental Stress Analysis	3
Mechanics of the Solid State	3
Technical Electives*	6
	12

*Of the 18 credits of technical electives, at least 6 must be selected in Design. Among the other electives suggested are several related to materials, such as Refractories, Physical Metallurgy, Metallurgical Engineering (II) and Physics of the Solid State.

Materials option *of the engineering mechanics course at Pennsylvania State University (1960-61). The materials option offers more technical elective credits than the mechanics option (18 vs 12). Up to 12 of these credits can be elected in materials courses.*

scientific theory for engineers. Although engineering is still, as traditionally, concerned with design, practice, utility and economy, the fact is that with the complexity of today's technology and industrial organizations, many engineers are doing types of work different from that conventionally associated with engineering as an art.

Another aspect of this trend toward a revision of the approach to the engineer's education is a movement in the direction of a single, basic four-year degree program for all engineers regardless of their eventual specialization in civil, mechanical, electrical or other fields of engineering. Some schools, such as UCLA, have already established such a single engineering baccalaureate. Others are working toward it in their own conservative way.

A third, and perhaps contradictory, aspect of change is the introduction of degree programs based on needs in some particular industry or end-service area. Examples are programs in nuclear engineering, aircraft and missile engineering, high temperature engineering, etc. However, such programs are preferably being introduced on the graduate level for work toward a master's degree or a doctorate. Within these programs the study of materials behavior is fundamental, and there are many who believe that there is no need for a separate and independent materials education program, but that the student should have enough elective courses —or perhaps an option—to enable him to concentrate heavily on materials study within the framework of the specialization he has chosen. This same approach can be taken, of course, within the more traditional fields such as mechanical engineering or physical chemistry.

Three Schools Have Undergraduate Curricula

For those who do believe in an independent materials engineering curriculum—and if they form a majority it is a slight one—the scale is almost completely weighed down on the side of graduate programs only. The only baccalaureate materials program currently accredited by ECPD (Engineer's Council for Professional Development) is that given at the University of Michigan. At Pennsylvania State University a materials option for the degree in engineering mechanics was introduced in the fall of 1959 and will undoubtedly be accredited when the ECPD next revises its accredited list. Similarly, Massachusetts Institute of Technology now has a materials option which is available to the metallurgical engineering student. In the past an MIT student could have designed his own materials "option" by judicious choice of elective courses from several disciplines. This is true of some other schools also; they just have not hand-picked the curriculum and spelled it out as a degree program option in the catalog.

Specific action, then, for degree programs in materials science or engineering on the undergraduate level is limited to the three universities mentioned. Other schools, however, are in the midst of curricula studies that will undoubtedly lead some of them to the same action. In a few universities it is the

SOPHOMORE YEAR

FALL

Analytic Geometry and Calculus	4
Introductory Analytical Chemistry	4
Physics—Mechanics, Sound, Heat	5
Statics	3
	16

SPRING

Analytic Geometry and Calculus	4
Physics—Electricity, Light	5
Mechanics of Materials	4
Electives	2
	16

SUMMER

Dynamics	3
Electrical Engineering	4
	7

JUNIOR YEAR

FALL

Introduction to Differential Equations	3
Physical Chemistry	3
Thermodynamics	3
Electives	7
	16

SPRING

Physical Chemistry	3
Measurements Laboratory or Methods of Instrumentation	3
Structure of Solids	3
Fluid Mechanics	3
Electives and options	4
	16

SENIOR YEAR

FALL

X-Ray Studies of Engineering Material	3
Introduction to High Polymers	4
Physical Metallurgy	4
Electives and options	6
	17

SPRING

Ceramic Materials	4
Physical Metallurgy	3
Electives and options	10
	17

Materials engineering *undergraduate curriculum of the University of Michigan (1960-61).*

specific intent of the engineering school to reach such an objective, possibly within five years, but it is not believed judicious to announce such an intent early in the nebulous planning stage.

In addition, it is probable that materials research contracts such as the recent ARPA (Army Research Program Administration) contracts awarded to Cornell, Pennsylvania and Northwestern Universities will lead eventually to further recognition of the need for undergraduate materials training.

There will always be some schools, however, who, mostly because of the size and nature of their student body, will not offer such a program even though they may feel that it would be a good thing if they were in a position to do so.

More Common: Upgrading Materials Courses

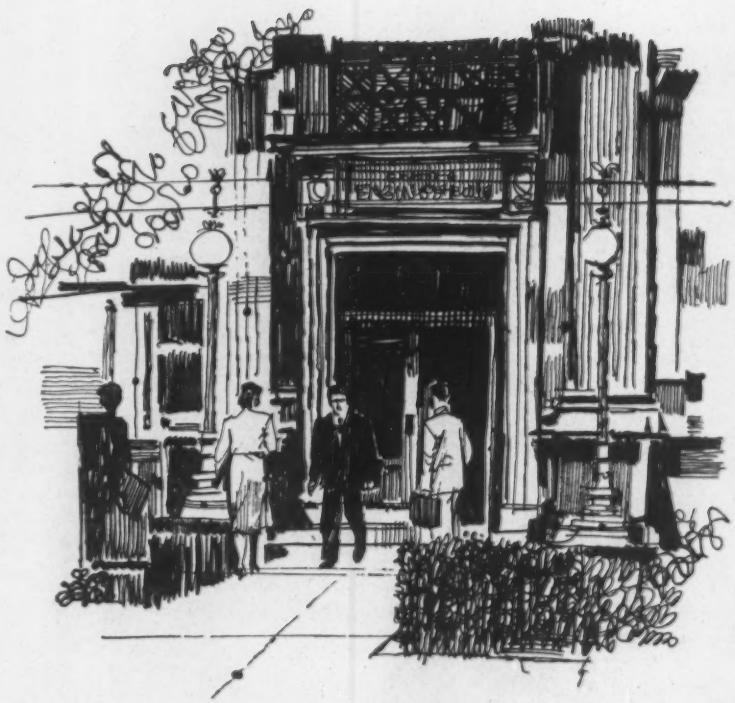
Much more evident at the universities at the present time is action on two other levels:

1. The one-semester or one-year materials course required of all, or almost all, undergraduate engineering students.

2. A materials degree program on the master's and doctoral level.

The first has been, or is in the process of being, put into action at every school visited. Although in some cases either one or all of three disciplines — civil, chemical and electrical—are excluded, plans are being made to present a specialized materials course to these as well.

As for graduate study in materials science, most of the universities now offer such a program which



in some cases is a direct program and in other cases is an option. Usually the degree does not specifically state that the major study was materials but is either a general Master of Science degree or a degree granted by one of the disciplines — e.g., mechanical, civil, chemical, aeronautical or metallurgical—from which it is possible to enter the graduate materials program. There are some universities, however, such as MIT which specifically grant a Master of Materials Engineering degree (Mat. E.).

Thus, although there is some hesitancy and delay in establishing a materials program on the undergraduate level, there does not exist the same sluggishness on the graduate level. In the view of Columbia University, if a school is going to undertake discussion of a certain subject on the undergraduate level, it should be prepared to offer continuation on the graduate level. Perhaps then, the present trend of the major universities is more indicative than some think. It may be just a question of putting the horse before the cart which is, after all, the safest and most convenient way.

*— J. C. Merriam**

**Formerly associate editor, Materials in Design Engineering.*

What Technical Societies Are Doing About Materials

Beyond the universities, the technical societies are the primary source of continuing education for many engineers in industry. How have the programs of these societies been affected by the Materials Age?

A survey by the editors shows that the materials societies are now putting more emphasis on the basic science of materials. The engineering societies, through flexible organization, have been able to organize research programs and new committees to cover the new materials and problems areas.

But despite these steps, there is considerable pressure for a new society to meet the growing needs of materials engineers.

Since the beginning of the Industrial Revolution technical societies have been a vital partner in technological growth. New technical societies are constantly being formed, and the older societies find it advisable, in many instances, to change their original scope and structure to reflect technological progress. This historic pattern of change in the technical societies has always been a testament to their foresight and flexibility.

How are the technical societies meeting the challenges presented by the growing importance of materials in our technology? Admittedly, this is a complex question. However, the answers that emerge from a recent survey of the leading technical societies seem to have a significant pattern. Four important conclusions become evident:

1. Engineering societies are showing great flexibility by forming a larger number of committees on the properties and application of materials. This emphasis stems from a greater awareness by designers and engineers that proper use of materials is often the key to the success or failure of a product.

2. Greater emphasis is being placed on materials education. This is reflected in the step-up in technical sessions on materials, in the larger number of publications devoted to materials, and in the increasing number of special materials education programs.

3. Materials societies are increasingly recognizing that more emphasis will have to be placed on the basic science and fundamentals of materials knowledge.

4. Materials and engineering societies are conducting more and more materials research directed toward end-service objectives.

Most Societies Are Flexible Enough to Expand

For a technical society to be effective it must grow with the times and must be sensitive to the latest needs of its members. Changes in emphasis, particularly in the materials field, can put a lot of pressure on the structure of a society. This pressure can be relieved only by the ability of that society to change, or by the formation of one or more new societies to meet the need. In many cases, of course, these things are not easily done.

New committees and divisions—By and large, existing technical socie-

ties seem to be successfully meeting this challenge of the Materials Age. Most societies have found that they can accommodate by suitable expansion the interest of members in new materials and new problems. Thus, we find an ever-increasing number of new technical committees and divisions being formed within the older societies.

A good case in point is the Research Executive Committee of the American Society of Mechanical Engineers (ASME)—a committee that has been active for many years. It is significant that most of the research committees that it has inaugurated recently deal primarily with materials problems. For example, just since 1956 the following research committees have been formed: ■ Prevention of Fracture in Metals ■ Behavior of Pressure Vessel Materials ■ Contact Fatigue on Rolling Elements ■ Effect of Radiation on Materials for Nuclear Installation ■ Mechanical Behavior of Metals.

The existence of these committees is a strong indication of the growing concern of engineers and designers with materials problems.

Another engineering society that has shown great flexibility in coping with materials problems is the Society of Automotive Engineers (SAE). This group has a separate General Materials Council composed of four materials committees: irons and steels, nonferrous metals, nonmetallics, and fuels and lubricants. Each committee covers a wide range of materials, and new divisions can be readily added in accordance with the needs of members and industry.

The great interest of SAE in materials is also reflected in the Materials Division of its Aero-Space Council. This division is designed to supplement the activities of the General Materials Council, particularly in the aerospace industries.

One of the greatest fruits of SAE's interest in materials problems is its well-known series of Aeronautical Materials Specifications. These specifications were started in 1939 and were instrumental in solving the special materials problems of the aircraft industry during World War II and thereafter. Almost 1000 specifications (about 98% are pure materials specifications, the remainder are processing specifications) are now in existence.

New programs—Many other examples of the flexibility of the technical societies can be cited. One seemingly incongruous example is the growing program of the American Society for Metals (ASM) in nonmetallic materials.

Many ASM members, though metals-oriented, are in a position where they have to select the best materials available to perform a particular job. Consequently they have to concern themselves with the whole materials picture, particularly in meeting new environments (such as space) where nonmetallics often do a better job than metals.

It is estimated that at least 10% of ASM's chapters are holding occasional sessions on plastics, ceramics and cermets. The nonmetallics discussed are usually those used in support of, or in conjunction with, metals. Since the society covers metals all the way from producer to user it has to be careful not to emphasize nonmetallics so much that it overlooks the basic needs of other members such as the metal producers.

Here are a few of the papers recently presented at local chapter meetings: ■ Epoxy Resins and Their Application ■ Modern Plastics ■ Plastics Use in Joining and Forming ■ A Metallurgist Looks at Ceramics ■ Problems in Ceramics.

Such topics probably cause some writhing among older members of ASM. But they are convincing proof of the openmindedness of members and the flexibility of the society's structure and planners.

Expanded objectives — In some cases a society may grow so much from its original base that it may have to expand on the objectives set by its founders. A good example is the American Society for Testing Materials (ASTM).

Formerly concerned primarily with the development of specifications and tests for engineering materials, ASTM recently recognized the growing importance of the science of materials by establishing a Materials Sciences Division. The purpose of this division will be to "focus attention and coordinate studies and discussion on the fundamentals of materials as distinct from engineering considerations." The division will cover all phases of materials science, including education, research, and dissemination of all pertinent information.

This new activity represents a unique change in ASTM's structure. It may be the first step in a rearrangement of the organization of

the society into divisions; such a program is being seriously considered by the society's Long Range Planning Committee and by its Board.

In its latest annual report ASTM says that the new Materials Sciences Division was needed in order to emphasize its long concern with materials fundamentals. It is hoped that the new division will provide a special place for bringing together scientists and specialists in different fields of materials. ASTM claims that it is in a unique position to provide a forum for materials specialists because traditionally its interests have cut across the entire materials field. Thus, it can provide a common ground for the physicist, the chemist and the engineer. That the new division appears to be meeting a genuine need is evidenced by the overflow attendance at two symposia it sponsored at the most recent annual meeting of ASTM in June.

Creation of this new division is only the latest step in a gradual broadening of the scope of ASTM activities over the years. Because these activities are broader than the name of the society would suggest to most people, many members feel that the name of the society should be changed. Several names have been proposed to better express ASTM's current materials activities. Typical of these (note that all retain the ASTM initials) are: Association for Standards and Technology of Materials; American Society for Standards and Technology of Materials; and, least different, American Society for Testing and Materials.

New Societies Are Sometimes Necessary

Many technical societies have been quite successful in expanding their activities without diluting them to such an extent that they do not adequately serve their members. Such success has been achieved by holding extra meetings for members with specialized interests, or by holding joint meetings with other societies. ASME has used the latter approach with great success in the belief that joint meetings can reduce duplication in subjects presented by different societies.

However, quite often it becomes apparent that one society alone cannot handle everybody's special interests and that a new society is in order. Such considerations in the past have led to the formation of the American Society of Body Engineers (Automotive), Institute of Aeronautical Sciences (IAS), the Society for Experimental Stress Analysis, and the American Society of Tool Engineers (recently broadened and renamed American Society of Tool and Manufacturing Engineers).

The SAMPE case — In recent months quite a controversy has been stirred up by the impending formation of a national Society of Aircraft Materials & Process Engineers (the "Aircraft" is already being changed to "Aerospace").

This society was formed locally in the Los Angeles area in 1944 to bring together professional people employed in materials and processing in the airframe industry. In the last few years similar chapters have been formed in other areas of the country. Last spring a steering committee representing all chapters decided that SAMPE should become a national society this fall but should not expand its scope to cover materials and processes in other industries. By fall SAMPE expects to increase its number of chapters from nine to twelve.

The pros and cons of SAMPE were thoroughly aired in the Oct '59 issue of M/DE. The main objections raised to the society were that it assumes that its materials processing problems are unique, that it rejects the cross-fertilization of ideas between materials and process engineers in unlike industries, and that it rejects the usefulness of established societies such as ASTM, IAS, SAE and the American Rocket Society.

This magazine disagreed with SAMPE's decision to restrict itself to the aircraft or aerospace industry. But it agreed with SAMPE that a national society encompassing a broad range of materials interests and organized on a local chapter basis was highly desirable.

According to H. R. Clauser, Editor of M/DE, "Such an organization will provide the opportunity for materials and process engineers to hear and exchange technical information and to discuss the everyday problems that are involved in the selection, evaluation and processing of engineering materials. It will promote the development and use of new and better materials. And, finally, it will increase the prestige of, and hasten a wider recognition of, materials engineering as a profession."

Societies for new materials — A more clear-cut case for a new society can be made when it is formed around a new and important group of materials. The outstanding recent examples are the Society of Plastics Engineers (SPE) and the Society of the Plastics Industry (SPI). It is evident that the needs of plastics producers, fabricators and users could not be satisfied within the framework of any other materials society.

In the case of SPE and SPI it is interesting to note that at the time these societies were formed there seemed to be a definite need for two separate groups. Time will tell whether or not this is the best arrangement. A combined organization of producers, fabricators and users has worked out to the benefit of all for ASM. Such a setup may yet be adopted in the growing field of plastics.

Ceramics, of course, are not new materials. But the growing interest in ceramics as engineering materials in a broad range of products and industries might be expected to cause some ferment. For years the American Ceramic Society has been producer-oriented. Now it has begun to place more emphasis on end uses and new applications, and thus to obviate the need for a new society in what is, to many engineers, a new field of materials.

Education Programs Are Getting More Emphasis

Many technical societies consider a national, local or committee meeting to be an educational program in itself. However, some societies, notably ASM and the American Welding Society (AWS), believe that there is a strong need for basic educational programs on materials and processes to meet the needs of members (and others interested) who are just getting into the field or who want to fill in gaps in their knowledge. In addition, such education programs permit the regular technical sessions to be conducted at a higher and more sophisticated level.

How ASM conducts its programs— One of the leading proponents of materials education programs is ASM. The success of its programs is a strong indication that people in industry may have a greater hunger for knowledge than many society leaders realize.

ASM's education program has many facets. One of the most important is the program of visiting lectureships that are offered to 63 colleges and universities (at their initiative) which have some type of metals education program.

Another facet is the educational lecture series for the local chapters. All chapters are encouraged to sponsor these lectures. Topics vary over a wide range from "Organizing and Running a Small Business" on through highly technical areas. A series may run from one day to a period of weeks, depending on the topic selected. Almost 80 ASM chapters are putting on at least one series a year.

There is also a growing trend in ASM whereby a local chapter (two examples are the Philadelphia and Trenton chapters) sponsors a materials course in a nearby college or university. The course is delivered by chapter members and ASM headquarters aids substantially by providing lecture outlines, books and slides. And, most important, ASM insures that the chapter does not lose any money.

AWS has broad program, too— Considering its size (about 13,000 members), the American Welding Society has a large number of education programs.

One important approach is to encourage local sections to present educational courses in welding, either by themselves or in cooperation with a local college or university. The local section provides its own outline and the course may be taught by an AWS industry member or by a college instructor.

Another extremely valuable program is the AWS School of Welding Technology. The five-day courses presented by the school are slanted to the needs of people with little welding knowledge and people requiring knowledge in a particular field.

Like the ASM courses, these courses have been found to be badly needed. Attendees (they do not have to be AWS members) say that the courses are "just what we have been waiting for."

AWS is also working on in-plant training courses to meet the different needs of different companies. The company indicates which course it would like to present and AWS supplies the course outline, makes materials available, and helps other ways as necessary. The course is given by someone in the plant and AWS does not police the instruction.

Student education is encouraged—The National Association of Corrosion Engineers (NACE) is interested in improving the materials education of high school students. It devotes considerable time and effort to sponsoring and assisting students in "science fair" projects. Furthermore, one NACE regional group has prepared a monograph series on corrosion which is written on a high school level and is intended to assist teachers in providing corrosion instruction.

Not to be overlooked are the time-tested student memberships that are available through some engineering societies, notably ASME, SAE and ASM. In light of the success of student participation it is surprising that more societies have not encouraged such programs. Most engineering students feel cut off from industry and many seem to welcome any opportunity to find out what technical problems and working environment they can expect when they graduate. Participation in the technical societies gives the student an opportunity to rub shoulders with practicing technical people and provides him with an excellent chance to learn how he can better guide and channel his studies.

Interest in Materials Science Is Growing

Some technical societies in the past have, of course, devoted much time and effort to basic studies of materials and related processes. Study of the older *Transactions* of the AIME (American Institute of Mining, Metallurgical and Petroleum Engineers) and the *Journal of the Electrochemical Society,* for example, will show this to be true. In recent years, however, both of these societies have put even more emphasis on the science of materials and materials fundamentals. In AIME, particularly, there is much work directed toward closing the gap between fundamental research and end-applications.

The energy and creativity shown by the Electrochemical Society on fundamental problems is evident to anyone who has attended its national meetings. The society has only 3400 members and operates on a very small budget (the major portion of which goes to the *Journal).* Yet its members, at a recent meeting, presented over 200 papers, many of them being of a fundamental nature.

There is also a noticeable trend toward fundamental materials studies in ASM. It is reflected both in the papers presented at regular meetings and in special seminars. One recent two-day seminar on the methods of strengthening in solids was aimed particularly at high level scientists and delved into realms that would have been thought out of bounds for ASM members not too long ago. A similar seminar on fundamentals, "Resonance and Relaxation in Metals," was held recently and the ASM seminar committee has others in the planning stage.

The formation by ASTM of a special division for materials sciences has already been mentioned. Though only one indication of the growing interest in fundamentals, it is probably the most dramatic action yet taken by a technical society to clear the way for positive programs in this field.

More Materials Research Programs Are Under Way

It is not often appreciated that the technical societies perform and instigate a great deal of important research. Because of inadequate funds, many societies cannot afford to do any individual research of their own. Fortunately, however, many societies have been able to develop research programs that are financed by industry.

Since the materials societies, which cut across industries, are often further removed from a particular industry than some of the engineering societies, which tend to be product-oriented, it is not surprising that they often have greater difficulty in obtaining funds for research. However, many members of such societies are able to interest their companies in individual research projects which, though in the basic research category, are of recognized value to the company.

Industry stands to gain a lot from such research. But it is sometimes unfortunate that industry sponsored research, however understandably, tends to be product-oriented.

In many cases industry financing of research is promoted by a research council which may or may not exist separately from a society. The AWS, for example, does not do any research of its own. However, the Welding Research Council, which is financed by industry and government grants, is able to take care of many research problems. The Council has no formal affiliation with AWS but does work closely with it.

Cooperative research programs sponsored by societies and industry (and in some cases the government) have had great success in meeting today's materials research problems. Many societies conduct such cooperative programs as a way of solving the research financing problem.

The ASME's program has been running for many years. Roughly 25 projects are currently under way and many are devoted to "hot" materials projects.

Here is how the ASME program works: The Research Executive Committee and Research Planning Committee decide on the problem, draw up a research program, estimate its cost, prepare a prospectus, and then arrange financing with the industry that will benefit most from the research. Once financing is obtained, contracts are drawn up and the projects are let out to an appropriate research laboratory. Progress reports may be issued during the program and all interested parties get a final report. Some of these projects run into hundreds of thousands of dollars and could not possibly be tackled by an individual company.

In many respects ASTM's research program is quite similar. Important research projects are determined by the technical committees and the needed money is obtained from ASTM funds or through special fund raisings. Dozens of research projects are currently under way, one of the most notable being a test program on full-size wood poles being conducted at the Forest Products Research Laboratory. Some $250,000 was raised through industry and government to carry on this program.

Another noteworthy ASTM research project is the Joint Research Committee on Effect of Temperature on the Properties of Materials which is being conducted with ASME. This Committee has just completed a fund raising campaign totaling $180,000 to carry out strategic research work over the next several years. — *R. J. Fabian*

The Materials Information Problem

If engineering education and the technical societies are faced with ferment for change, those in search of materials information today are faced with a tidal wave of words and figures.

The outpouring cannot be stopped — in fact it must be speeded up — but it must be brought under control so that its tremendous potential can be used efficiently. More and better evaluation of information, and more and better ways of finding it, are needed. These objectives call for changes in the laboratory, in technical meetings, in journals, in abstracting services, and in engineering departments.

The transmission of information is, in fact, a three-phase process in which the originator of information, the user of information and the media of communication between them all bear responsibilities that are steadily becoming more important in this, the Materials Age.

The "materials information problem" is not a new or unique problem that has been or will be solved. It is a continuing problem of communication that will exist as long as scientists and engineers are people. There can be no "solution" because maximum communicating efficiency is the aim. There will always be room for improvement.

At present most technical information specialists feel that we have reached a dangerous low in the efficiency with which we communicate materials information. The primary causes of this inefficiency have been discussed in other articles. Briefly they are:

1. The rapid increase in volume of new materials and materials information.

2. The development of the unified materials engineering approach, which requires an engineer to know about types of materials other than those with which he has been most familiar.

3. The urgent need (most strongly felt by the military) for new materials and new materials information as quickly as possible to meet severe design requirements.

Science vs Engineering: Two Distinct Problems

The scientists — Although many scientists agree that communication of scientific information on materials among themselves must be improved, there are those who question that this is a problem. G. S. Simpson, Jr., for example, writing in the *Battelle Technical Review* says:

"Is the great mass of scientific and technical literature being produced a real problem? If so, to whom? It is no longer enough to quote frightening statistics of the numbers of articles, journals, and books being produced. There is good evidence that our scientists—using the present "unorganized" independent, but effective, information net—are missing little of vital importance. They have their own effective methods and sources. Ask any scientist 'Who are the 10 or 15 most important scientists in your field?' or 'What research organizations are making the best advances in your field?' He will be able to give you the answers quickly and accurately. Moreover, those who need the information will be able to name the top men in their fields in other countries, as well. Thus, they know where to look for the information they need."

Simpson goes on to say, "Before . . . perhaps unneeded expenditures are further swollen, let us study the question from a scientific viewpoint. We need scientific evidence on such matters as the items of scientific information that have been missed by technologists, and the scientific value of such misses. We also need to know more about how scientists use the information they obtain from various sources."

An important point Simpson makes is that scientists working within specialized fields are in relatively close communication with other scientists working in the same or closely related fields. In any field of advanced knowledge, there are relatively few workers, simplifying communication.

On the other hand the unification of the basic sciences of materials has emphasized the need for, and shown the benefits to be derived from, cross-fertilization among the scientific disciplines.

The engineers—The materials engineer is a member of a much larger group. No longer is specialization such a help to him. In solving his pressing design needs, he must be aware of not only the materials he is used to, but of others he may know little about. Also, since traditional materials developed by industry for commercial use no longer meet all his design needs, he cannot

rely so heavily on materials producers' technical sales and service personnel. He must be aware both of developments in the more basic realm of the scientist, and of the experience of other engineers.

One engineer writes, in reply to a recent survey, ". . . A man who knows his field will know where to get materials information . . ." But a recent report by the Materials Advisory Board asserts that "while it is true that a specialist in any given field will know the principal contributors working in that field, there is no organized way for him to determine who is working on related subjects in a contiguous field for which he may have a legitimate need of new information."

With the unification of materials engineering, the need for such information from contiguous fields has increased substantially.

In summary, then, who most strongly feels the problems in lack of efficiency in communicating materials information? The MAB report says, "All materials groups, regardless of their scientific disciplines or materials category interests, are faced with these problems. However, the problems are generally less acute in the more academic atmosphere surrounding the research worker than in the atmosphere of urgency surrounding the engineer and the administrator."

There is also evident agreement that the information needs of the scientist differ from those of the engineer. The scientist relies more on oral communication and exchange of ideas; he also needs detailed original reports. The engineer needs more state-of-the-art summaries, evaluated and collated data, and answers to specific engineering questions.

What Are the Problems?

Of a total of more than 200 returns to an M/DE survey of materials specialists, 67% report that "finding and getting the right published information is a serious problem." But answers to other questions are not definitive in pinpointing any single most important cause of the problem.

In summary there appear to be three major problems which cause loss of efficiency in communicating materials information. Although these problems occur at various stages in the flow of information from source to end user, they are similar in nature and are the main points to be attacked in increasing efficiency of communicating. They are:

1. Time—Urgency of need for materials information has increased markedly; yet speed of communication of materials information to the end user has not increased proportionately.

2. Evaluation—Both degree and quality of evaluation need improvement. Lack of evaluation of the significance of information results in publication of unnecessary information in a report. It also results in duplication of publication. Result: an unnecessarily large volume of information to be searched.

Improper evaluation, on the other hand, results in omission of significant information in the published literature. Also, too often negative information which may be highly significant is screened out. Returns from the M/DE survey of materials specialists indicate that lack of sufficient technical detail is a major problem. Of those reporting, 85% said this was either an important or occasional problem; only 15% said it was little or no problem. Many of the respondents wrote in that lack of negative information about a material was an important problem.

3. Selectivity—The selection, collation and indexing of types of information of particular interest to specialized audiences within the materials field must be improved. Ideally, this function should be combined with that of evaluation, so that only significant work is reported to the specialized segments of the field.

These, then, are the major problems in improving efficiency of communication. To analyze what is being done—and what can be done—to overcome these shortcomings, it is necessary to take a look at the present materials information communication system.

Any communications system has: **a)** something to communicate—which comes from a source, **b)** the means of communicating it—media, and **c)** something to receive it—a recipient. Breakdowns contributing to loss of efficiency occur in each of these three basic areas. Thus it is worth exploring the nature of the problems existing in each of these areas.

Problem Area No. 1: The Information Source

The source of materials information is the daily research or engi-

neering work which usually results in notebook data. These data may go by way of informal discussion to seminars or symposiums, and then possibly to publication. Or they may go by way of progress reports to final reports, technical papers and finally journal publication.

The most important problem in this phase of communication is delay. Delay between notebook and seminar or symposium; delay between notebook and report; delay between report and technical paper; delay between technical paper and journal publication.

Another important problem is duplication of publication. The progress report becomes a final report, which in turn becomes one or more technical papers, which in turn become one or more journal articles. Such duplication can substantially increase the volume of recorded information without providing an appreciable increase in useful information.

Some such duplication can be worthwhile in terms of selectivity. In many cases, out of a given quantity of materials information, only portions pertinent to a specific audience are put together and presented to that audience. Other portions are put together for a different audience. In so doing, there is bound to be a degree of overlap. The problem with this type of published information is to identify it accurately enough when storing it so that the information user can select the reference with the proper content for his needs.

The many steps information goes through from laboratory to final publication pose an additional problem of evaluation. Information actually published is only a fraction of that originally generated. The material is usually screened, evaluated and edited by many people. These may include **a)** the original worker, **b)** his management, **c)** the society publication board, and **d)** the journal editor. On the one hand, much of this evaluation is necessary to limit the volume of information published; on the other hand, much information is lost this way. The possible value of the lost information depends on the technical judgment of the various evaluators involved.

Problem Area No. 2: The Communication Media

Seminars, symposiums and conferences—Meetings and conferences, both formal and informal, are one of the most effective methods for direct communication of materials information. In addition to the opportunities for floor discussion and two-way exchange of information and ideas, formal meetings usually stimulate informal personal discussions among materials specialists.

This medium has specific and quite stringent limitations. They are:

1. Amount and detail of information is limited by time (speech is one of the slowest means of communicating).

2. The number of recipients of such information is limited both by the facilities of the meeting place and by the time and money required to attend.

3. Much orally communicated information is lost, particularly information presented at seminars where the proceedings are not subsequently published.

4. Quality and organization of spoken information may suffer from lack of editorial review and subsequent disciplining.

Technical magazines and journals—Technical magazines and scientific journals communicate directly with materials specialists. They reach them by name through subscriptions or society memberships, or by the specialist's professional title. Evaluation and selection of information is dependent on the quality of the editorial staff of the journal or magazine.

Journals and magazines can be extremely effective in presenting one or more of the following: **a)** broad state-of-the-art reports, **b)** news reports on current materials developments, **c)** selected complete transcripts of important technical papers, **d)** references and abstracts of important papers, and **e)** selected evaluated materials data. They have several important limitations. These are:

1. *Number of magazines*—With the exception of M/DE, journals and magazines are devoted to only one or two technical specialties or disciplines within the materials field. The MAB report on dissemination of materials information refers to a listing of 25 technical societies and 14 trade associations, most of which publish at least one technical journal containing data relevant to the materials technologist. Added to these are the many commercial technical and trade magazines covering specialized areas of ma-

terials. It would be virtually impossible for the materials man to subscribe to all that might contain some information useful to him.

2. *Limited space*—Space in journals and magazines is limited. As the MAB report points out, "many of the original materials reports may be as large or larger than a complete journal issue." The journal must use the space it has for information of interest to the largest proportion of its readers.

3. *Delay in publication*—The time required for materials information to be published in journals and magazines depends on the type of journal and the type of information. In general, the shorter the delay, the fewer the technical details.

Abstracting services—A number of abstracting and indexing services serve to communicate directly with materials specialists, providing them with either an index to, or abstracts of, published information. These can effectively keep materials people abreast of developments within specific fields served by the various services.

The major limitation of such services is delay. Added to the initial delay encountered in publishing papers or articles in periodic journals, is the prepublication delay in preparing the index or abstract for publication.

Libraries and document centers—A number of technical libraries and document centers exist throughout the country. Their primary purpose is to collect, organize and index for maximum accessibility comprehensive collections of publications in technical fields. The facilities of some such centers are available to the public, e.g., the Office of Technical Services. Others are restricted by the interests of the supporting agencies or plants, e.g., the Armed Services Technical Information Agency which is limited to government military contractors.

Facilities of such libraries or document centers differ widely, ranging from simply making reference works available to providing detailed answers to technical inquiries.

Primary limitations of such libraries or centers include:

1. *Delay*—Since most such centers are primarily collectors of published information, the original lag between laboratory notebook and publication still exists. Also, the volume of information published creates a problem in rapidly assimilating all the information into the library or center.

2. *Lack of evaluation* — Although screening procedures differ, the majority of technical libraries and document centers collect and index all publications related to a field, with no critical evaluation of the worth of the information to users.

Consequently, although such centers are indispensable as a start in any literature search, they have obvious shortcomings in effectively keeping the materials specialist up-to-date on current important developments.

Problem Area No. 3: The Recipient of Information

The materials specialist, whether he is an engineer, a scientist, or a technician, must recognize his responsibility as a receiver of information. His is an active, not a passive, role. The purpose of improving the communicating of materials information is not to spoon-feed the end-user with specific answers to all his questions. The purpose is to *quickly* make available to him *significant* information about the nature and performance of engineering materials. The type, quality and quantity of the information should be clearly recognizable. But the recipient must:

1. Know where to look for what information.

2. Know what he's looking for in the way of information.

3. Recognize the information when he finds it.

In many cases a materials specialist will report that he did not know of certain published information; or that he finds published information hard to locate. In many such cases, the availability of the information may not have been properly publicized. But in other cases the engineer may not have done the research he should have done to determine the basic information facilities available to him.

What Is Being Done: A Broad Look

"Speeding up the collection and dissemination of scientific and technological information can best be done by expanding and accelerating the work of existing groups rather than by creating some new centralized . . . entity."

This comment from a recent

MATERIALS INFORMATION CENTERS

Centers	Subject Covered
Acoustical Soc. of Amer.	Acoustical materials
Aircraft Industries Assn. of Amer., Inc.	Aircraft (materials and parts)
Amer. Assn. of Textile Chemists and Colorists	Textile dyes and finishes
Amer. Ceramic Soc., Inc.	Ceramics
Amer. Chemical Soc.	Chemicals
Amer. Foundrymen's Soc.	Metal castings
Amer. Inst. of Electrical Engineers	Electrical and electronic materials
Amer. Lithium Inst., Inc.	Lithium
Amer. Soc. for Metals	Metals and casting design handbook
Amer. Soc. for Testing Materials	Test methods and standards for materials
Amer. Welding Soc., Inc.	Welding
Amer. Zinc Inst., Inc.	Zinc
ANC-5 (Battelle Memorial Inst.)	Test methods and design data on metals
ANC-17 (Forest Products Laboratory)	Test methods and design data on reinforced plastics
ANC-17 (Nat'l Bureau of Standards)	Test methods and design data on transparent materials
ANC-23 (Forest Products Laboratory)	Test methods and design data on sandwich construction
Armed Services Tech. Information Agency	R&D reports
Armour Research Foundation	Handbook on thermal properties of metals
Cobalt Information Center (Battelle)	Cobalt
Convair	Metal sandwich construction
Convair	Handbooks on radiation effects and shielding
Defense Metals Information Center	Titanium, beryllium, refractory metals, high strength alloys for high temp service, corrosion and oxidation resistant coatings, thermal protection systems
Engineering Societies Library	Engineering files
Forest Products Laboratory, Dept. of Agriculture	Adhesives, reinforced plastics, sandwich materials
Harris Research Laboratories, Inc.	Textiles; handbook of textiles
Inst. of Textile Technol.	Textiles
International Cobalt Information Center	Cobalt
Inter-Soc. Corr. Committee	Corrosion
Materials Advisory Board, Nat'l Research Council	All materials
Materials Central	Materials for air weapons
Nat'l Advisory Committee for Aeronautics	High temperature materials, rare metals, HEF
Nat'l Bureau of Standards	Variety of materials
Nat'l Paint, Varnish, and Lacquer Assn.	Protective coatings
Oak Ridge Nat'l Laboratory	Shielding materials
Office, Chief of Ordnance, Dept. of the Army	Handbook on rubber materials
Office of Tech. Services, Dept. of Commerce	Information on government research
Plastics Technical Evaluation Center	Plastics
Prevention of Deterioration Center	Natural deterioration
Radiation Effects Information Center	Effects of radiation
Soc. of the Plastics Industry, Inc.	Plastics
Southerly Regional Research Laboratory	General textile research
Tech. Information Service Extension	Nuclear radiation effects
Textile Research Institute	Textiles
Thermophysical Properties Research Center	Thermophysical properties
Tin Research Inst., Inc	Tin

This list, though not complete, gives 45 of the most important information centers concerned with materials and is indicative of the fields served. Societies listed include only those with a "search facility." Other societies can be helpful, however.

report to the National Academy of Sciences summarizes the attitudes of most qualified investigators in the materials information field. It also emphasizes that the problem in materials information is to increase efficiency of present methods, not overhaul the entire system. For though the growth of the unified materials concept has increased the complexity of communication, it has not introduced any radically new problems.

Each method of communicating has its advantages and its limitations. Each serves a specific need. Each must be used properly. And finally, each must be improved in efficiency.

The means by which efficiency should be increased are spelled out in the summary recommendations made by the MAB in its "Final Report on Dissemination of Technological Information about Materials and Materials Research."

In brief, the report recommends that the Dept. of Defense:

1. Sponsor information and technical evaluation centers, as needed.

2. Materially assist existing technical libraries, especially by compiling and distributing several types of information about materials.

3. Assist scientific personnel and technical reporters in the preparation and publication of materials information.

4. More actively coordinate materials information services.

5. Strengthen contractors' technical information facilities.

6. Sponsor basic studies leading to

improved methods of evaluating information.

The report also recommends that contracting officers consider the adequacy of technical information services before awarding contracts.

A great deal of time and money is being spent in improving efficiency of communicating materials information. Space does not permit a complete discussion of all the major efforts in this direction. However, several outstanding approaches will be mentioned.

Mechanization and Automation Save Time

A great deal of time and money has been spent on the development and application of machine-handling of literature and information. For example, the Armed Services Technical Information Agency has recently laid the groundwork for a massive transition to automation. The result will be the machine-handling of 1200-3500 daily requests for reports from its store of nearly a million documents, which is growing at a rate of 30,000 titles per year.

Another outstanding example is the American Society for Metals' Metals Documentation Service, developed at Western Reserve University. The purpose of the center is to provide a selecting, abstracting and searching service covering the world's published metallurgical literature. The Service, based on machine searching of literature, will provide **1)** biweekly abstracts of all current publications pertaining exactly to the subscriber's metallurgical problems, and **2)** ultimately overnight bibliographic searches of all metallurgical documents published in preceding years. Just recently this service was expanded, with the help of a grant from the National Science Foundation, to cover areas close to metallurgy, such as chemistry, physics and mathematics.

These are only two of the many efforts in this direction being made by government, technical societies, libraries, and industry. These projects are primarily aimed at solving one problem: the problem of the time lag in organizing and retrieving the tremendous volume of information that is now being generated.

Although these efforts are necessary, they do not affect two important problems:

First, since the systems are based primarily on published information, they do not reduce the delay in getting results of work from notebook into print.

Secondly, such systems do not provide for evaluation of information. In describing the ASM's service in *Metal Progress,* Miss M. R. Hyslop writes, "No attempt will be made to *evaluate* information critically . . . –that would be the function of the recipient, his staff or consultants."

Materials Information Centers: A Promising Approach

Materials information centers—such as the Defense Metals Information Center, and the Plastics Technical Evaluation Center—are one of the most promising approaches to improving most of the limitations in communicating materials information.

The unique nature of these centers stems from their ability (and responsibility) to actively seek out information, both published and unpublished, collect, *evaluate,* and disseminate it. Also,

What You Can Do to Help

As a materials man, you have responsibilities both as a source and as a receiver of information. Remember that just as you must seek and use materials information, others are concerned with the work you *do.*

As a source of information you can:

1. *Carefully evaluate all the information you present either orally at meetings, or written in reports. Remember that each piece of information you contribute adds to the store of information available. Make sure your contribution is* succinct, *properly* identified, *and* summarized *in brief abstract form. Yet make sure all the pertinent detail is included.*

2. *Try to get it out of your notebook and into some more available form as soon as possible. If you are in a supervisory capacity, urge your subordinates to get the results of their work out of their notebooks as soon as possible.*

As a recipient of information you must *know where to get what information. With the number of different information media that can be useful, this in itself can be quite a problem. Beyond finding out what media are available to you, you have to know how best to use them and what kinds of information they do and do not supply.*

Getting this information itself is time-consuming. But in the long run the time spent will more than pay for itself. The communicating media are useless unless used – and used properly. And they are there for you to use.

theirs is the responsibility for identifying areas where additional efforts are needed in research and development programs. Certain centers may also, on assignment, conduct surveys or laboratory research investigations, mainly of a short-range nature.

Thus, they go several steps beyond the conventional library or document centers. In essence, they form a relatively complete informational bridge between the source of technical information and the receiver.

According to the MAB report, such a center may on occasion have recourse to: "**1)** supplementary laboratory investigations of its own devising, **2)** conferences with other experts, or **3)** the original source of the information for more detailed elucidation of the question at hand."

A similar approach, but one having a different orientation, is the centers organized to provide information on materials properties or performance irrespective of the type of material. Such centers also actively seek information from the original worker, and evaluate, summarize and disseminate it.

The Thermophysical Properties Research Center, at Purdue University, is probably the most outstanding example of such a center. Supported by both industry and government, the center's ultimate aim is to collect, analyze, correlate and disseminate all thermophysical property information on all materials. It also provides facilities for research to fill gaps in the world's knowledge of these properties.

Another example of the performance-oriented information center is the Radiation Effects Information Center at Battelle. Established by the Air Force, the center provides a rapid means of placing radiation effects data in the hands of weapons system designers and those conducting research and development.

Under existing organizations, most materials information centers are somewhat limited in that they are sponsored by the government, for the most part the military. Consequently, their facilities are primarily available to government contractors, and potential contractors. The Thermophysical Properties Research Center, being in effect jointly owned by many interests, both governmental and private, is not so limited.

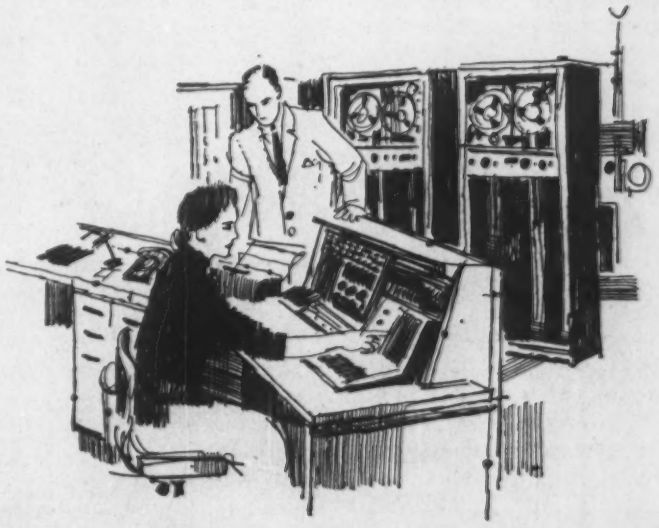
These two types of information centers complement one another. The performance or property-oriented center provides basic information on all types of materials in terms of one or more specific performance parameters. The material-oriented center provides up-to-the-minute, evaluated information on developments within that category of materials.

Awareness: Greatest Sign of Progress

Awareness that an information problem has been created by the growth of the materials concept is possibly the most promising sign of progress. Particularly promising is the growing awareness that the problem is not only one of properly coding and programming computers to more efficiently handle the volume of information, but also one of improving the efficiency of communication between people—and, that it is a problem of great complexity.

Among the more important indications of such awareness are:

- The emphasis placed on the problem by the Committee on Scope and Conduct of Materials Research



in its report "More Effective Organization and Administration of Materials Research and Development for National Security." This report was prepared for the National Academy of Sciences—National Research Council.

■ The study and findings of the Committee on Dissemination of Technological Information about Materials. A committee of the Materials Advisory Board, it reported to the Director of Defense Research and Engineering.

■ The emphasis among the various branches of the military on organizing and communicating on a broader materials basis, rather than in specific materials categories. For example, the Air Force has recently established a Materials Central at Wright Field to encompass all materials problems in developing air weapons. Materials research summaries, such as "Review of Materials Research of the Ordnance Materials Research Office," are also becoming more common.

— M. W. Riley

Acknowledgments and References

The editors of MATERIALS IN DESIGN ENGINEERING *are pleased to acknowledge particularly the assistance of the following persons, organizations and publications in preparing the staff-written contributions to this special report:*

This Is the Materials Age

Baker, W. O., "The National Role of Materials Research and Development," presented at ASTM Annual Meeting, June 26-July 1, '60.

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Education of the Materials Engineer

The literature of and about many universities, and papers by many professors, were consulted in the preparation of this article. In addition, publications by the Engineering Council of Professional Development and the American Society for Engineering Education were used as reference. Finally, the editors would like to thank the various individuals from the following schools who freely gave their time to personal interviews: Columbia University, Massachusetts Institute of Technology, New York University, Northeastern University, Pennsylvania State University, Princeton University, Rensselaer Polytechnic Institute, University of Michigan, University of Pennsylvania.

What Technical Societies Are Doing About Materials

Much of the information in this article was based on personal interviews with: Robert Painter and Frank Speight, American Society for Testing Materials; Allan Ray Putnam and T. C. DuMond, American Society for Metals; O. B. Schier, II, American Society of Mechanical Engineers; Joseph Gilbert, Ray Stoner and John Meldrum, Society of Automotive Engineers; John Nichols, American Electroplaters' Society; Melvin Kohudic, Society of Plastics Engineers; Ernest Kirkendall, American Institute of Mining, Metallurgical and Petroleum Engineers; Robert Shannon, Electrochemical Society; and Arthur Phillips, American Welding Society.

The Materials Information Problem

The assistance of John C. Green, Director, Office of Technical Services, U. S. Dept. of Commerce, both in original discussions and in final review of the manuscript, is greatly appreciated.

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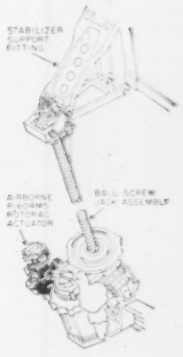
SAVES SPACE AND WEIGHT

An excellent example of the trend to compact, lightweight power drives is provided by the special actuator developed by Airborne Accessories Corporation, Hillside, New Jersey for trim systems on the Boeing 707.

Airborne uses a variety of miniaturization techniques. One of their most important tools in making smaller, more reliable drive motors, however, is Dow Corning silicone insulation. The use of silicone insulation on these high performance motors assures utmost reliability under almost continuous off-on-reverse type operation . . . helped designers provide up to 50% more power per pound . . . helped them tailor performance of the motors against inertia of all rotating parts and load. This silicone insulated actuator has a 4.25 inch frame, weighs only 13.2 pounds with brake, is rated continuously to 2.5 hp, 11,000 rpm, and intermittently to 6 hp, 9,000 rpm.

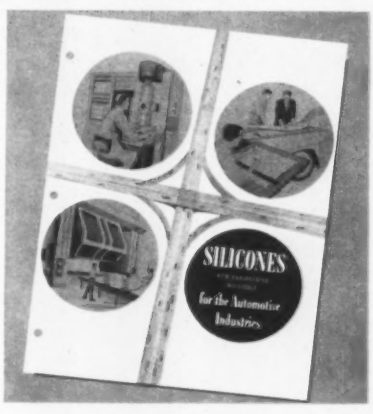


Another drive motor that Airborne engineers have designed to be lighter, more compact and more reliable through the use of silicone insulation . . . a specialized compressor motor weighing a mere 8.8 pounds . . . delivers 1.7 hp output continuously at 10,900 rpm and in ambient temperatures up to 160 F.

(Cont. Pg. 2)

Silicones in the Automotive Industries

How silicones, with their somewhat higher initial price, gained widespread acceptance in the cost conscious, high volume automotive industries may well be the materials success story of the last decade. But whether it is or is not the story, it makes interesting and stimulating reading in the new 8-page reference, "Silicones For The Automotive Industries", just released by Dow Corning Corporation.



Colorful and well illustrated, this new brochure describes how silicones in various physical forms are helping designers of autos, trucks and other land vehicles solve some of their most difficult engineering problems. Applications for silicone products in production equipment

(Cont. Pg. 2)

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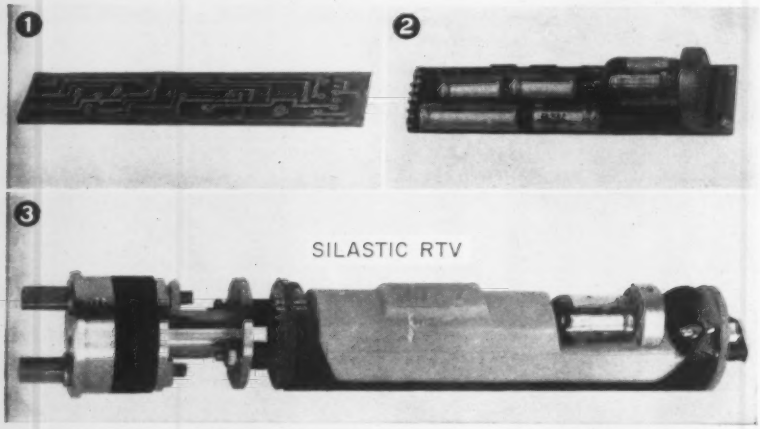

PACKAGES AND PROTECTS

How best to "package" high gain preamplifier components for severe duty service within strict space limits? Vitro Laboratories, Silver Spring, Maryland, found the answer to be encapsulation with Silastic® RTV, the fluid silicone rubber that cures at room temperature.

Vitro Laboratories' preamplifier consists of a vacuum tube and three transistor stages containing a total of twenty-five parts. Design specs called for a neat package no larger than 1-7/16" diameter by 5" long. Desired operating characteristics: high insulation strength, heat stability, and resistance to shock, vibration and moisture.

All of these requirements are met conveniently and easily by Vitro engineers through mounting the components on a printed circuit board, then encapsulating the board and all with Silastic RTV.

The procedure is simple. After securing all components and testing them, the board is placed in a two-piece plaster mold. A "window" is blocked out to permit easy access to the vacuum tube. The fluid Silastic RTV is then poured into the assembly in a slow, steady stream until the mold is completely filled. A moderate amount of heat speeds vulcanization so that the unit is completely cured in two hours and requires a minimum of trimming.

Silastic RTV provides a "professional-looking" package . . . and more important, it soaks up shock and vibration, dissipates heat and effectively locks out moisture. It retains its fine physical and dielectric properties under adverse environmental conditions. By exerting a firm grip on preamplifier components, Silastic RTV eliminates the need for a number of space-consuming clamps and brackets. Another feature: The resilient silicone rubber allows easy tube replacement. *No. 242*

AUTOMOTIVE *(Continued)*

and as aids to manufacturing and maintenance are also outlined.

While prepared especially for designers of autos and auto production equipment, this new reference will be of interest to engineers in any field because it explains how the properties and forms of silicones combine to make possible new concepts and new freedom in design engineering.

For a free copy of "Silicones For The Automotive Industries", circle . . *No. 243*

SILICONE INSULATION *(Continued)*

Airborne further assures the reliability of its specialized drives by using closely toleranced motor bearings featuring heat-stable and noncorrosive silicone lubricants which exhibit an extremely low viscosity characteristic at —65 F. *No. 244*

new literature and technical data on silicones

Flight Designs — The rapidly expanding uses for silicones in aircraft and missile design are described and illustrated in a new brochure, Silicones Solve Space Age Problems. Thirty application stories, each with detailed illustration, graphically demonstrate advantageous uses of such silicone products as compounds, fluids, lubricants, protective coatings, rubbers, resins, potting materials and sealants . . . provoke thinking how designers may adapt these versatile engineering materials to improve performance, make good products better. *No. 245*

Design Versatility — Lightweight, strong, inert, and easy to fabricate, silicone-glass laminates are used in the design and manufacture of a variety of consumer and industrial products. Applications, tables of physical and dielectric properties, illustrations of various parts, and sources of silicone-glass laminate parts are included in a four-page brochure. *No. 246*

How Silicones Work for the CPI — This manual is the first and only description of silicones for the chemical process industries. It cites how various forms of silicones help design, process and maintenance engineers expand capacity, cut costs, increase reliability, and improve job conditions. Here's a management tool that's a must for all engineers in all phases of the CPI. *No. 247*

Tapes That Stick — Dow Corning silicone pressure-sensitive adhesives make tapes stick to anything. They help achieve serviceability over a wide range of temperatures, resistance to oxidation, weathering, corrosive chemicals, and retention of good dielectric properties. For complete information on the properties of tapes made with Dow Corning silicone adhesives, and their applications, circle . . . . . *No. 248*

Compiled for Advanced Research and development engineers, an eight page reference provides a convenient guide to selecting the most suitable silicone fluid medium when designing damping, springing, coupling and related mechanical devices. Includes tables, graphs and detailed information about properties that enable Dow Corning silicone fluids to increase efficiency of existing designs and make possible new design changes. *No. 249*

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Variation of Thermal Conductivity with Temperature

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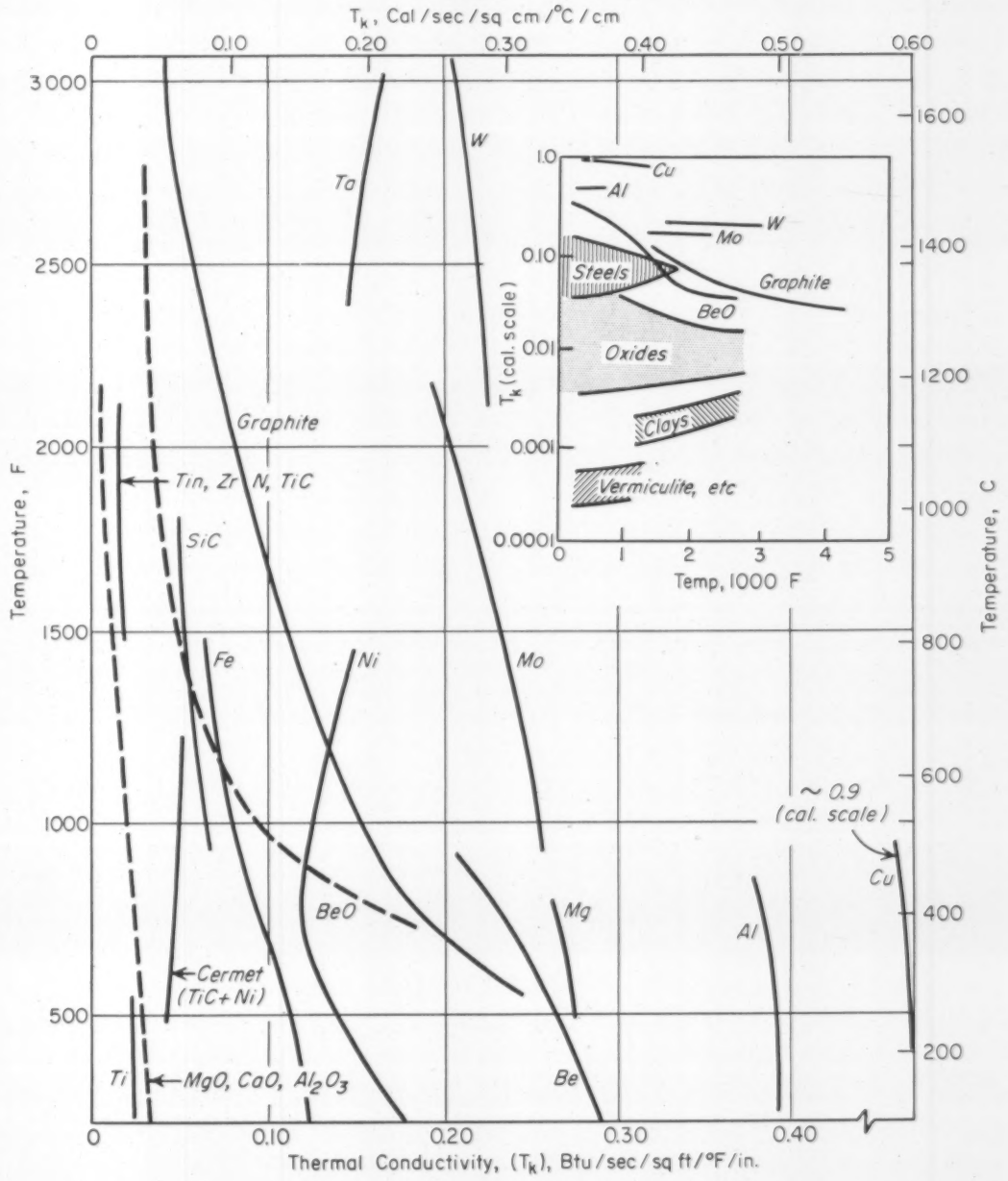

Courtesy, W. S. Pellini, Superintendent, Metallurgy Div., U. S. Naval Research Laboratory

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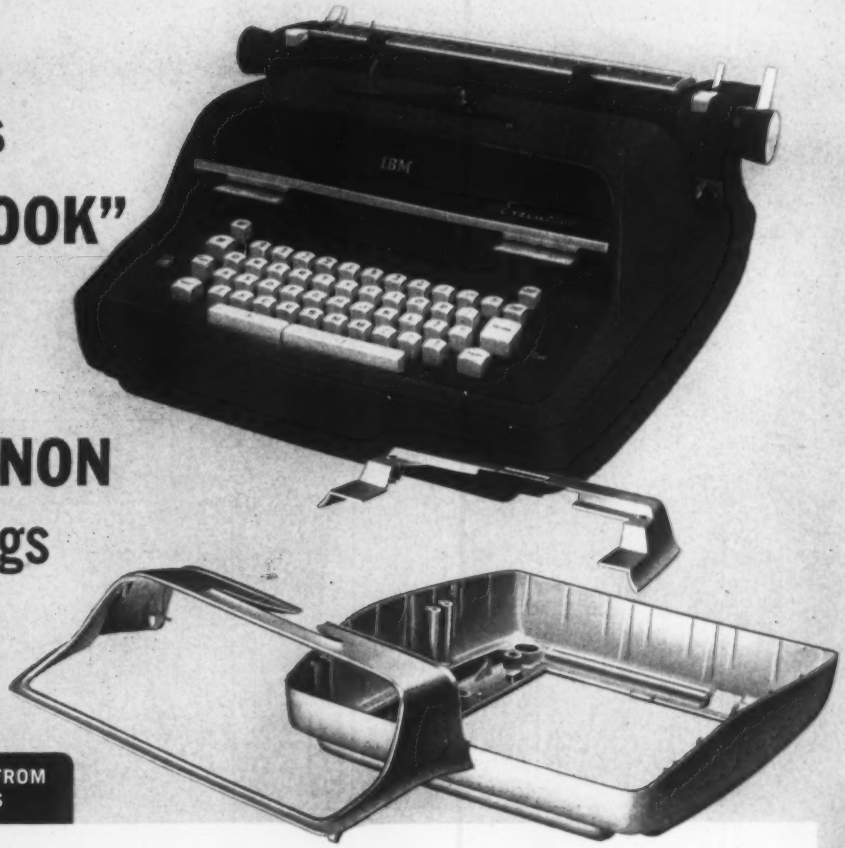

CASE HISTORIES FROM MT. VERNON FILES

Behind the sleek silhouette of the dramatically new IBM electric typewriters is "more than a quarter of a century of experience . . . a combination of styling and engineering advances" that promise — and deliver — better performance and easier typing.

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MATERIALS AT WORK

...AT A GLANCE

Urethane foam pads are cushioning the tremendous jolts caused by arresting cables as they slam violently against the deck after catching and stopping jet fighters aboard Navy aircraft carriers. The ¾-in. thick urethane pads, vulcanized to ¼-in. steel plate, are said to provide a higher tensile strength and about 8-10 times the abrasion resistance of the best available rubber. In addition, urethane has excellent weathering and aging properties. Overall dimensions are 18 × 52 in.

Source: B. F. Goodrich Industrial Products Co.

Over 300 tons of insulated galvanized steel sheets have been specified for the combination air terminal-storage buildings now being built at important bases along the Distant Early Warning (DEW) Line, north of the Arctic Circle. The 2 ft, 8 in. wide panels contain 3 in. of insulation to maintain a temperature of 70 F and a humidity of 50%, even though outside temperatures drop to −60 F. The outer skin consists of galvanized steel sheet to which asphalt-impregnated asbestos felt is bonded with a molten zinc coating. This is then covered with a waterproof coating. The inner face is 18-gage galvanized steel.

Source: Committee on Galvanized Steel Sheet Research.

Ceramic-coated mufflers and tailpipes, scheduled to be installed on all 1961 Rambler autos, are said to be virtually impervious to corrosion and are expected to last the life of the car. The mufflers are dipped in the ceramic in such a way that both outer and inner surfaces (including baffles and tubes) are coated. The coating is then fused to the metal in a continuous furnace at 1500 F. After coating, a layer of asbestos insulation and the outer zinc-coated cover are applied to the muffler.

Source: American Motors Corp.; ceramic exhaust system developed jointly by American Motors, Walker Mfg. Co. and Bettinger Corp.

A natural mica disk is used to "anchor" components in the electron gun assembly of a special type of cathode ray tube. The assembly consists of the 0.015-in. thick stamped mica disk, a nickel retainer-aligner and several nickel eyelets. Natural mica was selected as the insulation because it offers high dielectric strength, stability up to 1000 F, and excellent mechanical properties at all temperatures. In addition, mica's ease of fabrication permits tolerances of ±0.001 in. to be easily held.

Source: Ford Radio & Mica Corp.

'Frozen' rubies may be the key to a tenfold increase in range of masers —electronic devices used to detect radio signals from outer space. The two-carat synthetic ruby, which is cooled to –452 F and placed inside the maser, is said to be capable of detecting radio beeps from space vehicles millions of miles away. The low temperature, maintained by immersing the ruby in liquid helium, causes atoms and electrons in the gem to move in slow motion, resulting in an almost static-free signal booster. Whereas conventional masers use a 500-lb magnet costing $4000, the new device uses a 12-oz magnet costing about $10.

Sources: Dept. of the Army and Hughes Aircraft Co.

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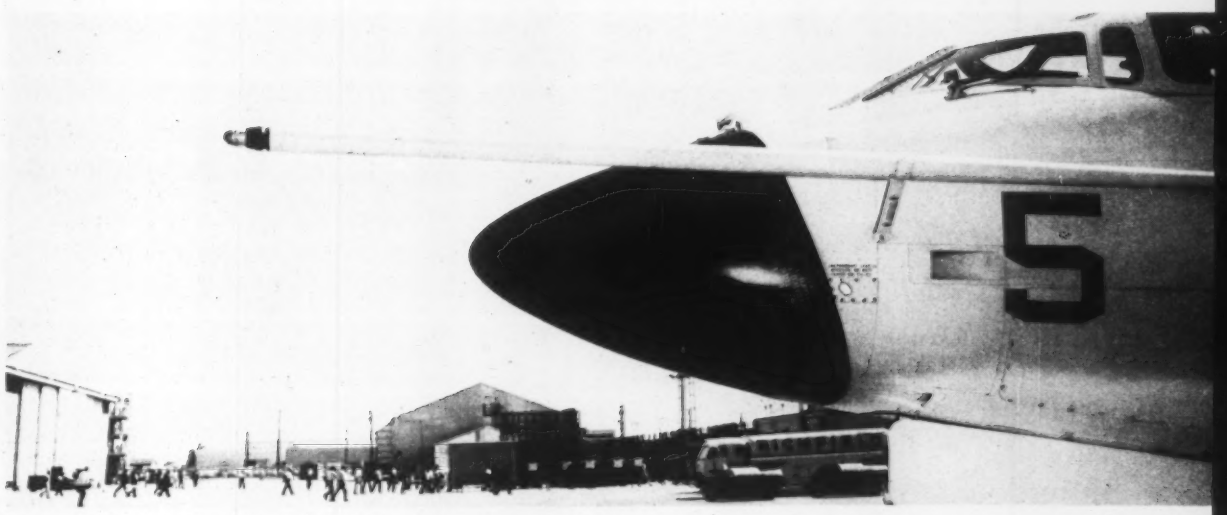
Long Aluminum Extrusion Forms Aircraft Fueling Probe



***Fuel probe** with tapered bore extruded from aluminum.*

■ Exploiting a secondary characteristic of hollow extrusions—the inner taper—enabled Douglas Aircraft Co. engineers to make a long, light, taper-bore fueling probe for the A3D attack bomber, faster and cheaper.

Design of the in-flight fueling system called for a probe that would extend almost 14 ft from the Skywarrior's fuselage to well beyond its nose. The tip of the probe had to fit into the tanker airplane's drogue (4 in. i.d.) and the rear bore was restricted to 3½ in. to maintain pressure during fueling.

The probe has to withstand stresses of flight loads, in-flight fueling impacts, catapult launchings and arrested carrier landings. As most of the forward length is cantilevered, the finished wall thickness at the point of maximum load must be held to ¼ in. and the thinnest wall to 0.090 in.

Machining, swaging rejected

Various types of fabrication were investigated but the extreme mounted length, 165 in., limits the method of taper. Machining the bore would be slow and costly and present problems of concentricity, wall thickness and finish. Swaging techniques proved unsatisfactory.

The first successfully manufactured design was a 4-in. dia extrusion with a 5/16-in. wall. The outside was machined for weight reduction but there was no internal taper. Static tests showed that the design was good but permanent set took place before 100% proof load.

Tapered extrusion the answer

It was then decided to extrude the probe and exaggerate the small inner taper inherent in all extrusions to achieve the desired dimensions. Engineers of Aluminum Co. of America designed an extrusion with a constant o.d. of 4 in. and an i.d. of 2.900 in., tapering first to 3.500 in. in 69 in., followed by another taper to 3.657 in. in the next 141 in. and then a constant section of 3.657 in. for 24 in. Particular care was taken to maintain the critical volume-length ratios and tolerances for each taper step.

Aluminum 2014-T42 was chosen over 2024-T42 for its formability, elongation after heat treatment and stress corrosion properties. It was also preferred to 6061-T6 for higher ultimate strength and better elongation after the heat treatment. After extrusion, the probe was heat treated, roll straightened, machine tapered on the outside, and threaded for attachment.

Probe is strong, precise

The finished probe had 14 separate concentricity nodes varying from 0.005 in. to 0.030 in., and the maximum allowable deviation from straight was 0.14 in. in the full tube length.

In static tests the tip of the probe was deflected 11.69 in. at 100% load. At 150% load the deflection was 19.21 in. There was no permanent set when these loads were released. The probe was loaded 250% in a destruction test when the support bolts failed and the test was discontinued.

Plastics, Aluminum Lighten Portable Typewriter

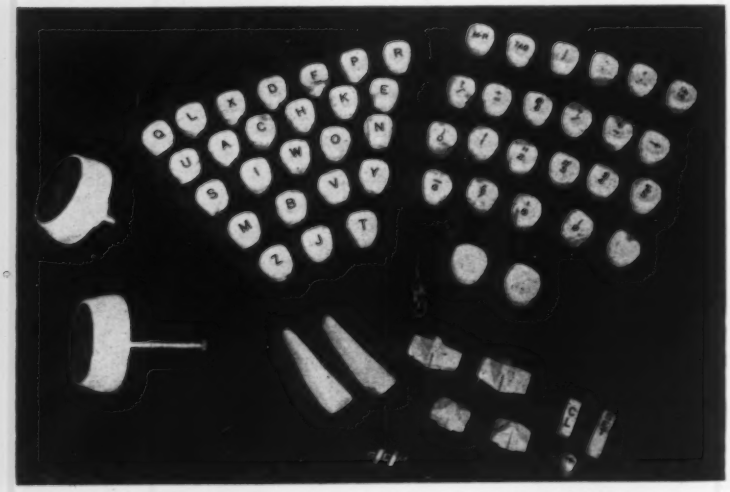
Careful attention to materials selection by design engineers of Smith-Corona Marchant Inc., has resulted in a new typewriter weighing only 12 lb—1 lb less than the deluxe model it replaces and as much as 3 lb lighter than competitive portables in its class.

Two years of research in human engineering and studies of contemporary office typewriters were required for the new "Galaxie" typewriter design. And, as the accompanying photos show, the materials for each component were chosen to provide the lowest possible weight combined with maximum durability. Furthermore, by using non-resonant materials such as aluminum and plastics, designers were able to obtain a soundproofing effect which permits practically noiseless typing.

Aluminum is being used for the first time in the new design for such parts as base jacket, ribbon spool cover (bonnet), carriage cover and return lever. Rubber strips are interlaced through the aluminum base to reduce vibration and eliminate movement.

Both the base and the spool cover are coated with a textured vinyl paint which cuts down glare and resists wear and abrasion. A unique design feature of the ribbon spool cover is that it is not hinged like conventional typewriters but is designed to slide forward to provide greater accessibility.

Faster and easier shifting is obtained by using a light die cast aluminum segment (not shown) in place of the cast iron segment used in other machines. This segment is raised when the shift button is pressed for upper-case characters; when made of aluminum it can be moved with less effort and fatigue by the operator.

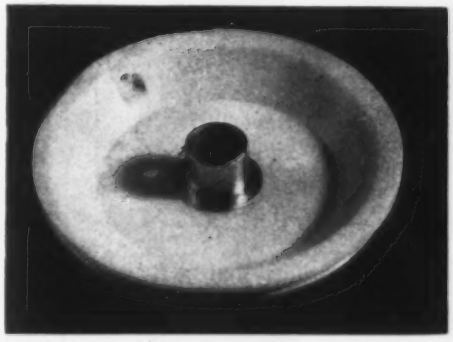


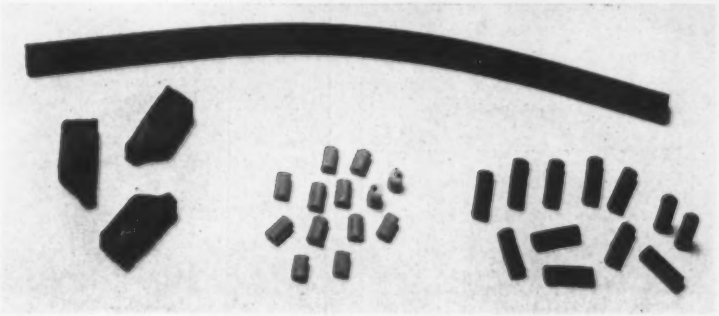
Butyrate proved to be the logical choice for parts that are subject to repeated handling by the operator. The material has a warm, pleasant touch and its good impact resistance prevents fingernails from chipping, scratching or marring the keys and levers. It also is unaffected by contact with the inks, cleaners and chemicals commonly used in an office.

From an appearance standpoint butyrate proved ideal because of its soft, glare-free look, and its integral, fade-proof color. The material's low cost and moldability were also key selection factors.

Methyl methacrylate is used for the keyboard mask and carriage end covers of the new typewriter for a number of important reasons. No matter how good they are, paints in the keyboard area are susceptible to damage because of the large amount of handling occurring in that area. Consequently, methyl methacrylate was chosen to provide a wear and stain resistant surface and to keep the machine new-looking for a longer period of time. Also, the material is odorless and has a high sheen. Its relatively high heat distortion temperature is advantageous in that the mask must be sprung into position and maintain its dimensional stability under adverse conditions.

ABS plastic is used in one critical typewriter part—the carriage cord drum assembly. The material is exceptionally tough and strong, and, of particular importance in mass production items, it is inexpensive and has excellent moldability.





Polyvinyl chloride proved valuable in the new design because of its toughness and ability to be formulated in varying degrees of hardness and flexibility. The long PVC part at the top is a type rest cushion and must have relatively high flexibility. The keyboard mask cleats at the left are bit harder and help dampen vibration between the keyboard and base. The rigid PVC parts in center are paper bail roll retainers; the softer parts at right are the paper bail rolls.

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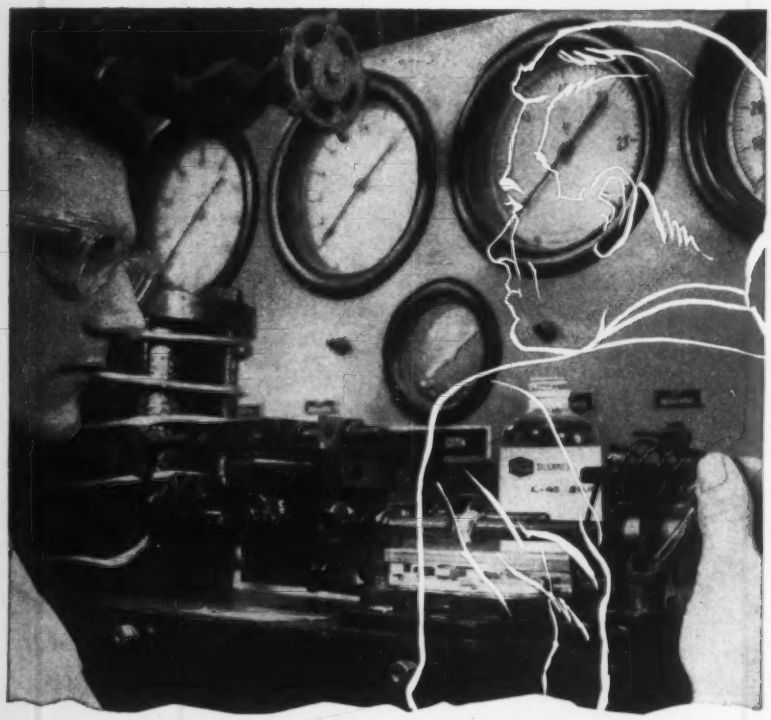

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MATERIALS AT WORK

Large Power Rectifier Uses Glass-Polyester

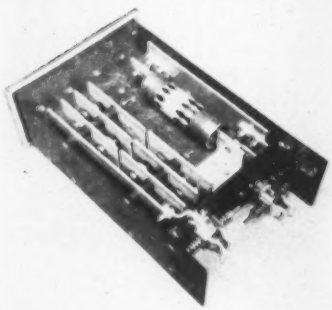
Fire resistant glass-reinforced polyester laminates have been specified for various components of the largest silicon power rectifier developed by General Electric Co. (see accompanying photo).

Materials selection for the rectifier fell into three categories:

1. Draw-out trays—Each tray consists of four pieces of 3/16-in. glass-polyester laminate used as supporting and insulating members for the silicon cells and fuses (see photo). The entire installation uses 384 of these trays.

Design requirements called for an insulating material that was punchable and possessed fair mechanical properties, good electrical properties, and good flame and arc resistance. Glastic Corp.'s UTS laminate, using Hooker Chemical Corp.'s Hetron fire-resistant polyester resin, satisfied all requirements.

2. Insulated baffle plates—These parts, used to direct air flow through the desired paths within the rectifier cubicles, are made of ⅛-in. thick



Draw-out tray.

Section of rectifier unit.

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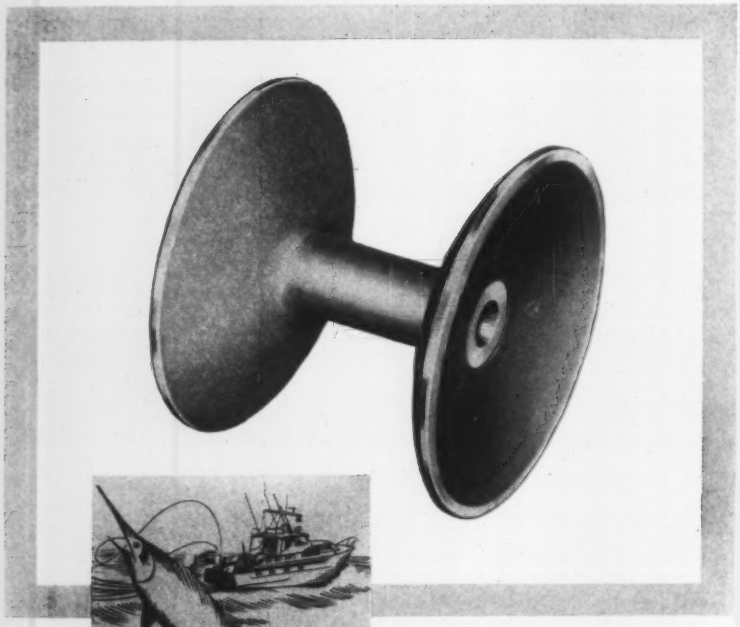
LOOK what brass is doing now!



Tough brass for the big fish!

Here's a *unique* deep-sea fishing reel spool converted to a Titan brass pressure die-casting. Fishermen found that the previous spool of the reel buckled under convulsive pressure of deep-sea marlin and tuna on modern fishing lines.

Stronger, wear-resistant, corrosion-resistant Titan brass die casting solved the problem. In fact, the higher strength of this die casting allows even thinner, streamlined spool sections. And here's the unique part: It's a spool in *one piece!* . . . all because of Titan brass ingenuity.

Like advantages can be yours when you switch to Titan brass pressure die castings. Let us help design and quote on your component parts.

Call your nearest Titan Man for detailed data and a brass die casting quote, or send your sample and blueprint to Bellefonte, Pa., or Newark, Calif., for fast service.

Send for latest folder on Titan Pressure Die Castings

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OFFICES & AGENCIES IN PRINCIPAL CITIES
45 years of quality brass

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UTS glass-polyester laminate.

3. Supports for main electrical conductors—These supporting members are about 4 ft long with a 4 × ½ in. cross section. Specifications called for this material to have good mechanical properties in addition to good electrical characteristics. Glastic's grade GF glass-polyester laminate satisfied all requirements.

According to Glastic, flame resistant glass-polyester laminates were selected in preference to flame resistant phenolic laminates because of their superior impact strength and greater retention of properties after heat.

Barium Fluoride Film Makes Electron Visible

A thin film of aluminum-supported barium fluoride is the key to a unique light-amplifying device that is said to be so sensitive it can make visible a single electron released by a single photon.

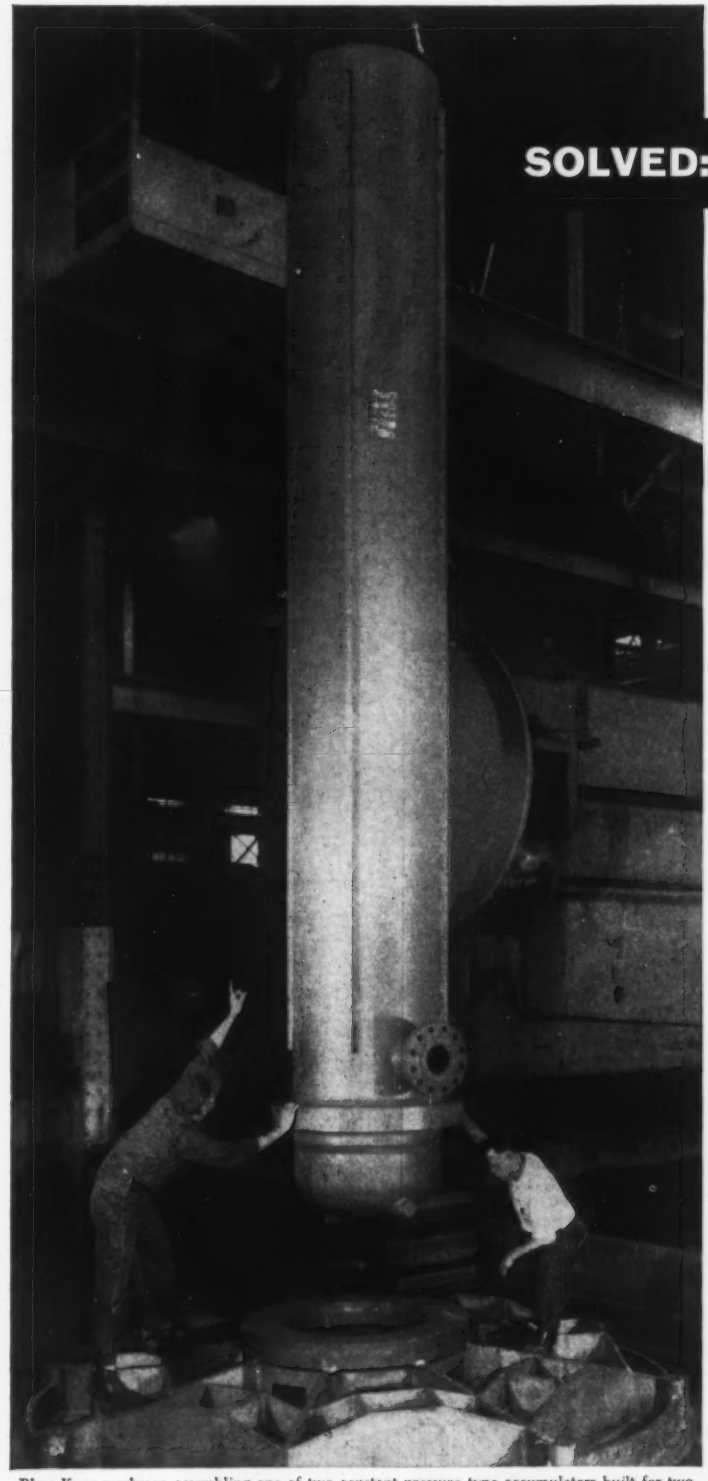
How it works

The device, called the Astracon and developed by Westinghouse Electric Corp., is actually a small electronic tube that operates on a principle discovered by Westinghouse several years ago. The image of an object, so dim that it is invisible to the naked eye, is focused by lenses onto a light-sensitive screen at the input end of the tube. The individual particles of light, or photons, coming from the image strike the surface and eject electrons from it.

Barium fluoride is key

Each of the ejected electrons is accelerated forward by 2000 v and

Light-amplifying device *makes visible a single electron released from a single photon.*



Blaw-Knox workmen assembling one of two constant pressure type accumulators built for two of America's largest steel mills. Sandusky supplied the straight cylindrical sections for both.

SOLVED: by Sandusky Centrifugal Casting

Blaw-Knox chooses 10-ton

SANDUSKY CASTING

for giant slabbing mill

When an 18½-foot cylinder was needed for a new giant Universal slabbing mill built by Blaw-Knox Company's East Chicago (Indiana) Works for a well known steel mill, they found that the most practical and economical way to meet all requirements was with a Sandusky Centrifugal Casting.

This 10-ton carbon steel cylinder, 32" O.D. with a 3½" wall, functions as an accumulator in the mill's hydraulic roll balancing system. Essentially a pressure vessel, it simultaneously supports the ram and ballast weighing 226 tons—the weight required to develop constant operating pressure of 1000 p.s.i.

"Only a dimensionally stable, one-piece cylinder could perform satisfactorily in this service," a Blaw-Knox official asserted. *"Distortion could lead to binding, loss of pressure and costly downtime. Sandusky's ability to produce this heavy walled cylinder in one 18½ foot length met all our requirements of cost, stability, and strength."*

Sandusky cylinders up to 33 feet long —from 7" to 54" O.D.— and in a wide range of ferrous and non-ferrous alloys —may well be the answer to *your cylindrical problems,* too.

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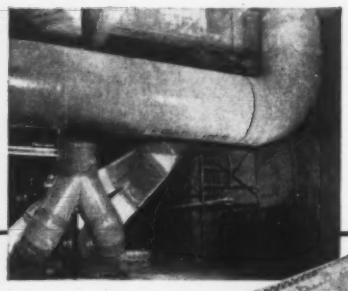

in the
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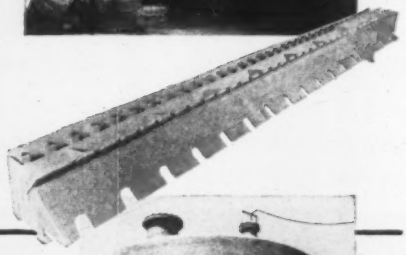
industry

Complex rayon spin machines, feed pipes, filters, screens, tanks and similar equipment are fabricated from Duracor.



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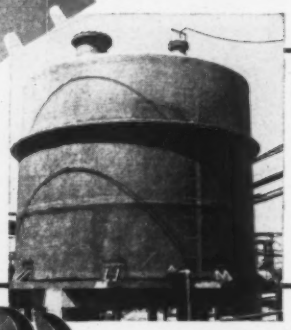
Acid storage tanks, tank trailers, exhaust systems, pressure pipes and other Duracor products are rendering outstanding service.



in the
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Duracor is used extensively for special processing equipment, processing tanks, laboratory sinks, brine tanks, acid storage tanks, covers and ventilating systems.

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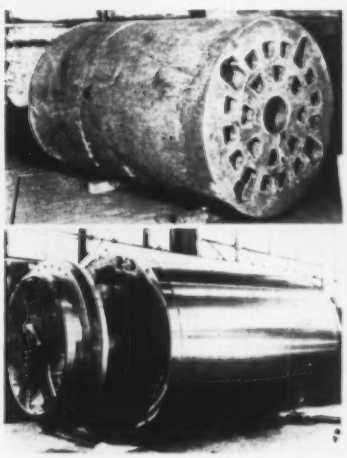
MATERIALS AT WORK

strikes against the two-layer film. The film, only a few millionths of an inch thick, consists of barium fluoride supported by a thin layer of aluminum. Barium fluoride is the key to the tube's operation and was selected because of its high secondary emission ratio and inertness. The aluminum layer serves to support the fluffy barium fluoride compound and was selected because it is a good conductor and can be easily made thin.

When the high speed electrons crash into the film, they penetrate into the barium fluoride and release four or five additional electrons. These are accelerated into a second film (or dynode) where the electron multiplication is repeated.

Light amplified 20,000X

By using five such steps, a single electron is multiplied into about 3000. These are given a final 20,000-v boost and aimed into a thin layer



Largest ductile iron cylinder—Shown above are as-cast and finish-machined views of one of the largest cylinder castings ever made of ductile iron. The casting, to be used as the impression cylinder in a new four-color printing press, weighs 32,420 lb, and measures 60 in. in dia and 88 in. long. According to Advance Foundry Co., ductile iron was selected because of its excellent surface characteristics after machining and its excellent dimensional stability.

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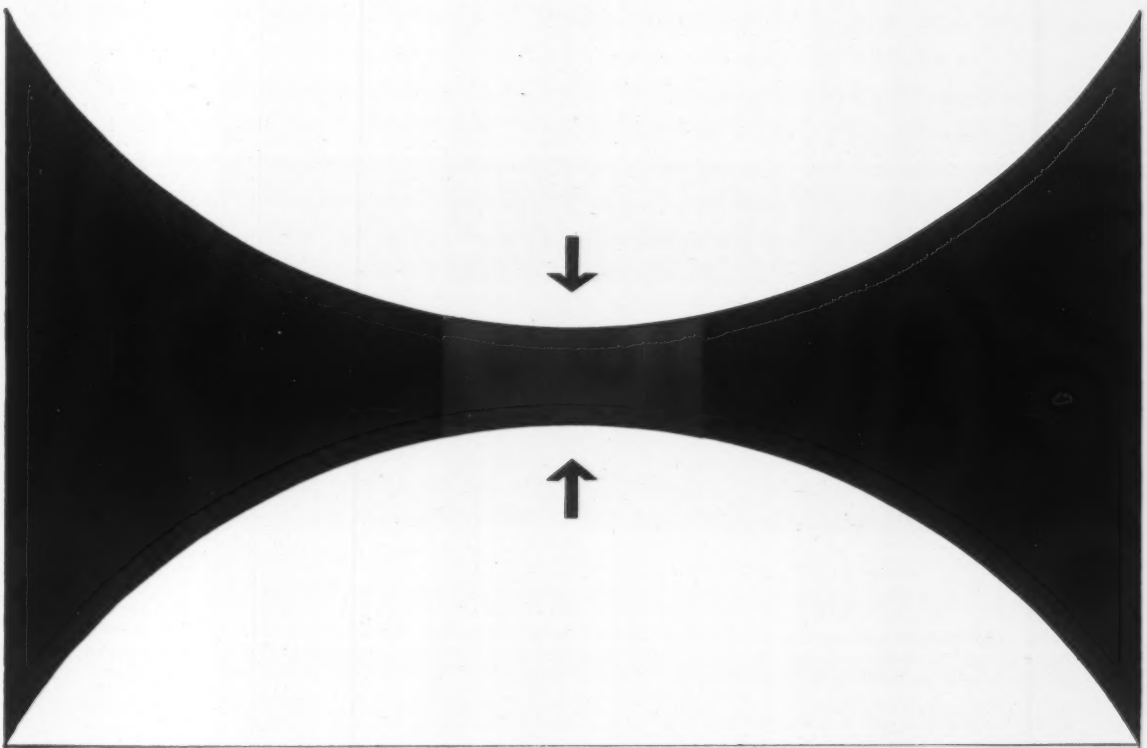

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of fluorescent material at the output end of the tube where they release 20,000 or more photons of visible light. Thus a dim, invisible image striking the input can be reproduced thousands of times brighter at the output.

In addition to amplifying and making visible dim light, the device is significant for another reason: it makes it possible for the first time to view individual electrons (actually they show up as flashes of light).

Potential uses for the Astracon are in astronomy, where it can increase the effective size, or light gathering ability, of the largest telescopes; and in nuclear physics where it may, for the first time, permit tracks of high energy cosmic rays and other particles to be viewed.

Phenolic Laminate Replaces Cast Iron

A switch from gray iron castings to molded asbestos-reinforced phenolic laminates has resulted in reduced costs and longer life of brake assemblies used on earthmoving equipment.

According to LeTourneau-Westinghouse Co., the decision to switch materials was based on a desire to improve service life of the equipment. In the brake assembly, air pressure applied to a backing plate squeezes a rubber diaphragm against a cast iron pressure plate, which in turn applies pressure to the friction elements. The friction elements consist of alternately-placed lined and molybdenum-coated steel disks.

When forced together by air pressure, the friction elements provide the braking action.

Too much frictional heat

The problem to be overcome in this assembly was failure of the rubber diaphragm due to excessive heat generated by the friction disks and transferred by the cast iron pressure plate. Two solutions were possible: 1) replace the rubber diaphragm with a more heat resistant material, or 2) use a different kind of pressure plate.

The first attempt to prolong diaphragm life involved replacement

New bearings made with TEFLON® last over five times as long as conventional bearings in kiln oven at 370°F.

A paper company's insulation board passes through a kiln oven (370°F.) on rollers supported by 2,000 saddle bearings. Material formerly used cost $2.10 per bearing. Average life: 1½ years. Failure of these bearings frequently caused damage to the steel stub shafts, which then had to be replaced or refinished. Additional cost: estimated at about $0.75 per shaft. Cost per year: well over $1.50 per bearing, plus the additional cost of labor and downtime.

After a thorough program of evaluation, bearings of a filled TEFLON TFE resin were installed. First cost: $3.25 per bearing. After two years of service, the new bearings are still performing perfectly and the shafts show no wear whatsoever. The paper company estimates the service life of the reinforced TEFLON bearings to be at least 10 years. Cost per year: less than $0.33 per bearing.

TEFLON TFE resins offer an exceptionally low coefficient of friction, virtually complete chemical inertness, high-temperature performance up to 500°F. Bearings of TEFLON are usually tailored for increased loads and velocities or high wear resistance by the use of reinforced constructions and filled compositions. And they make possible performance advantages and cost savings like those cited above.

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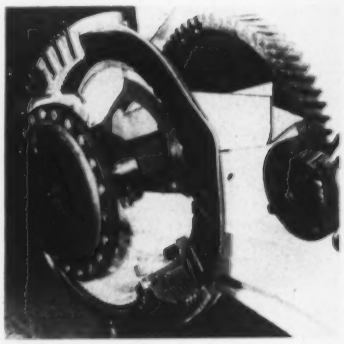
MATERIALS AT WORK



***Grooved pressure plate** is key member of brake assembly.*

of the rubber with a glass-silicone composition capable of withstanding 500 F. Although this material performed satisfactorily, it was quite expensive (about ten times more costly than the original rubber part), and the second possibility was investigated.

Laminate is grooved

At the suggestion of Raybestos-Manhattan, Inc., slabs of asbestos-phenolic laminate were tried. These performed satisfactorily, but did not dissipate heat fast enough to allow use of the original, inexpensive rubber diaphragms. Next suggested was grooving the asbestos-phenolic laminate in contact with steel disks. This was much better: in addition to dissipating heat more rapidly, the grooves allowed easy removal of dust, chips, small stones and other substances encountered in the field. However, due to material waste and machining costs, the final part was molded to the desired shape.

According to Raybestos, the switch from gray iron to asbestos-reinforced phenolic laminate not only prolonged equipment life, but provided these advantages: high thermal insulation, dimensional stability, excellent heat resistance, and the elimination of costly machining and other handling operations previously necessary.

SOURCES of most engineering materials can be found in the third edition of M/DE's *Materials Selector* reference issue, published last October. Properties of all materials are also given.

SIMPLIFY LOW-TEMPERATURE SILVER BRAZING WITH THESE SPECIALLY DEVELOPED FLUXES!

The correct selection of flux can offer unexpected help in speeding and simplifying production, minimizing rejects and lowering costs in low temperature silver brazing operations. The advantages to be gained by "selective fluxing" are *sufficiently important to warrant careful, thorough study!*

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Silvaloy fluxes are packaged in 65-lb. and 30-lb. drums, 5-lb. wide mouth jars (5 to a carton), 1-lb. and ½-lb. jars. The wide opening of the 5-lb. package makes it a most practical, time saving dispenser that also enables the operator to make use of every bit of flux in jar.

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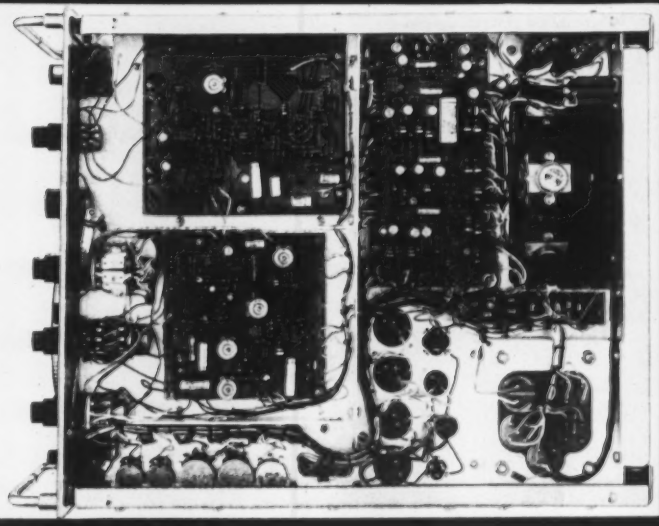
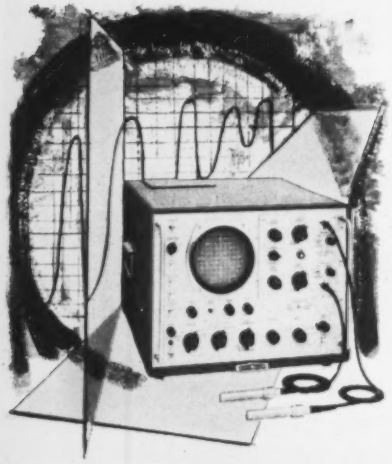
Textolite® 11558
copper-clad laminate



Photos of model 185A oscilloscope courtesy Hewlett-Packard Company



The Hewlett-Packard Company has developed a sampling oscilloscope that has a rise time of less than 0.7 millimicroseconds. Known as Model 185A, it is highly useful wherever pulse analysis of fast circuits can speed engineering, research, design, or performance testing.

Because of the extreme accuracy demanded of the 185A, etched circuits must be absolutely dependable. Base laminate requirements, according to Hewlett-Packard, were: "high bond strength, low water absorbtion and high insulation resistance". Tests proved the reliability of G-E Textolite 11558 copper-clad laminates for the application.

Easy-to-machine, 11558 is a NEMA G-10 glass-epoxy laminate available copper-clad on one or both sides. It combines extremely high mechanical strength with excellent electrical properties and resistance to moisture. G-E *engineered cleanliness* assures a smooth continuous copper surface.

For information on 11558 copper-clad or information on the complete line of Textolite laminates consult Sweet's Product Design File, Cat. 2b/Gen., or write: Laminated Products Department, Section MD-90, General Electric Company, Coshocton, Ohio.

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ENGINEERING & DESIGN

New Data on Why Metals Fracture May Lead to Improved Alloys

The National Bureau of Standards, U. S. Dept. of Commerce, Washington 25, D. C. has accelerated its program of fundamental research on the mechanical properties of metals in order to obtain new data on the fracture of metals. Information derived from the research is expected to yield practical methods for improving the performance of metals. The information is also expected to be of help in developing new alloys.

Instabilities in alloys, changes within the space lattice at the atomic level, surface reactions, the creep process, metal fatigue, and all factors controlling the response of metals to external forces are being investigated.

Some of the work being done at the Bureau is summarized briefly here.

Grain boundaries do not promote cracking

Aluminum specimens with grains 2 to 3 μ in dia have been made at the Bureau so that the behavior of individual stressed grains could be observed more readily.

In one study with these specimens, individual grains were found to act independently of their neighbors. There was no evidence that grain boundaries or interaction with neighboring grains promote cracking. According to NBS, the principal factor to be considered in fatigue crack initiation of polycrystalline aluminum is "the resolved shear stress on the plane of easy slip in the slip direction."

Bubbles form at same time fatigue cracks are initiated

In other work, the Bureau found that if transparent tape is applied to the surface of a fatigue specimen, bubbles form under the tape at about the same time that fatigue cracks are initiated. The bubbles, caused by the liberation of gas at the surface of metals, are expected to provide a useful means for studying chemical reactions at the surface of metals.

Results of another study showed that the preponderance of fatigue cracks starting at the edges of a metal specimen is caused by the stress pattern, rather than by the lower fatigue strength at the edges.

Titanium is very notch sensitive at low temperatures

The Bureau has conducted several investigations at temperatures down to —320 F to evaluate the combined influence of prior strain-temperature history and notch geometry on the tensile behavior of commercially pure titanium and a titanium alloy containing aluminum and manganese.

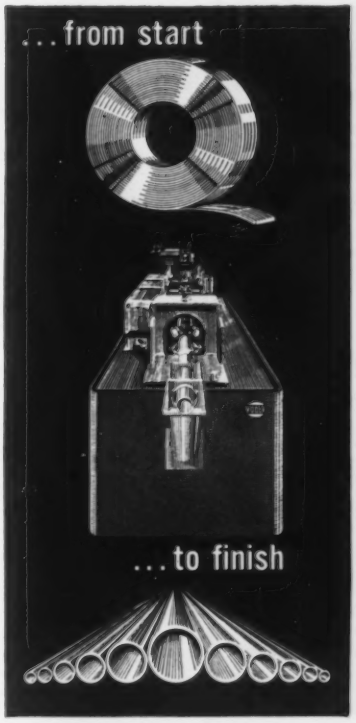
Measurements of strength and ductility characteristics showed that strength indices, i.e., resistance to flow, notch strength, true stress at maximum load, and fracture stress, are generally increased, and tensile ductility is decreased, by increasing notch depth or by lowering the test temperature. The data indicate that titanium is very notch sensitive at low temperatures.

Details of the Bureau's work on the fracture of metals may be found in Rpt. No. STR-2446.

Porcelain Enamels Protect Magnesium

Information on recent developments in protective finishes for magnesium was revealed by P. F. George of Dow Metal Products Co., Div. of Dow Chemical Co., Midland, Mich. at a meeting of the Magnesium Assn. held in New York last fall.

Of special interest was his report on the porcelain enameling of magnesium. Magnesium has been enameled successfully by using either a lead oxide or a lithium phosphate



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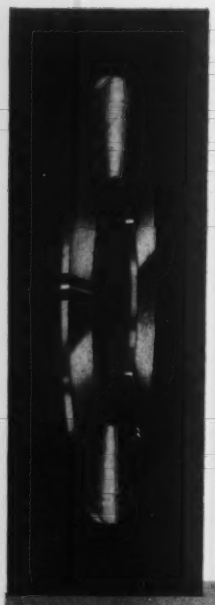

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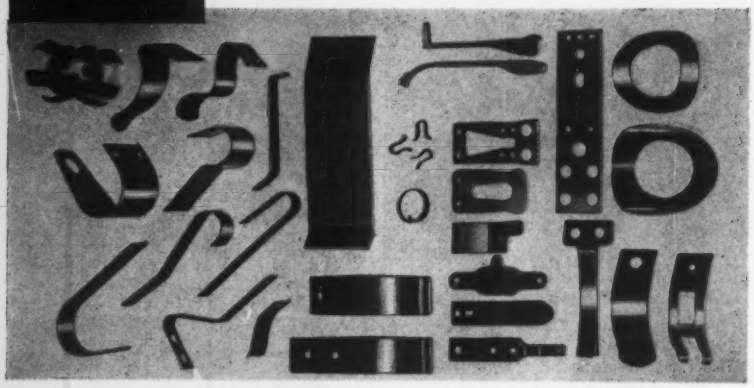

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In addition to the wide variety of qualities and sizes carried in stock, Sandvik has local facilities for custom-processing and finishing to your requirements.

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type of coating (see M/DE, Mar '60, p 189).

The firing temperature of these materials is below 1000 F, which makes it possible to use the coatings on most magnesium alloys except AZ63, AZ91 and AZ92. A pretreatment to insure good adhesion has been worked out for wrought alloys AZ31, HK31 and HM21, and cast alloys EK30, EZ33, ZE 41 and HK 31.

The lead oxide type of enamel affords excellent corrosion protection on magnesium. After 500-hr salt spray testing, panels with bare edges showed little edge corrosion and no noticeable spalling or undercutting because of corrosion at the edges. Tests in industrial and rural atmospheres showed no corrosion after six months exposure.

The lithium phosphate enamel has been applied to magnesium cooking utensils because it is nontoxic. Tests show the coating withstands repeated heating and cooling cycles.

The two coatings have not yet been applied to magnesium in production.

Mr. George also revealed that tin-plated steel fasteners are better to use with magnesium than cadmium or zinc-plated steel fasteners. He says the tin plate does not corrode off steel fasteners as fast as cadmium, and only 0.00025 in. of tin is needed.

How to Fabricate Vanadium Metal

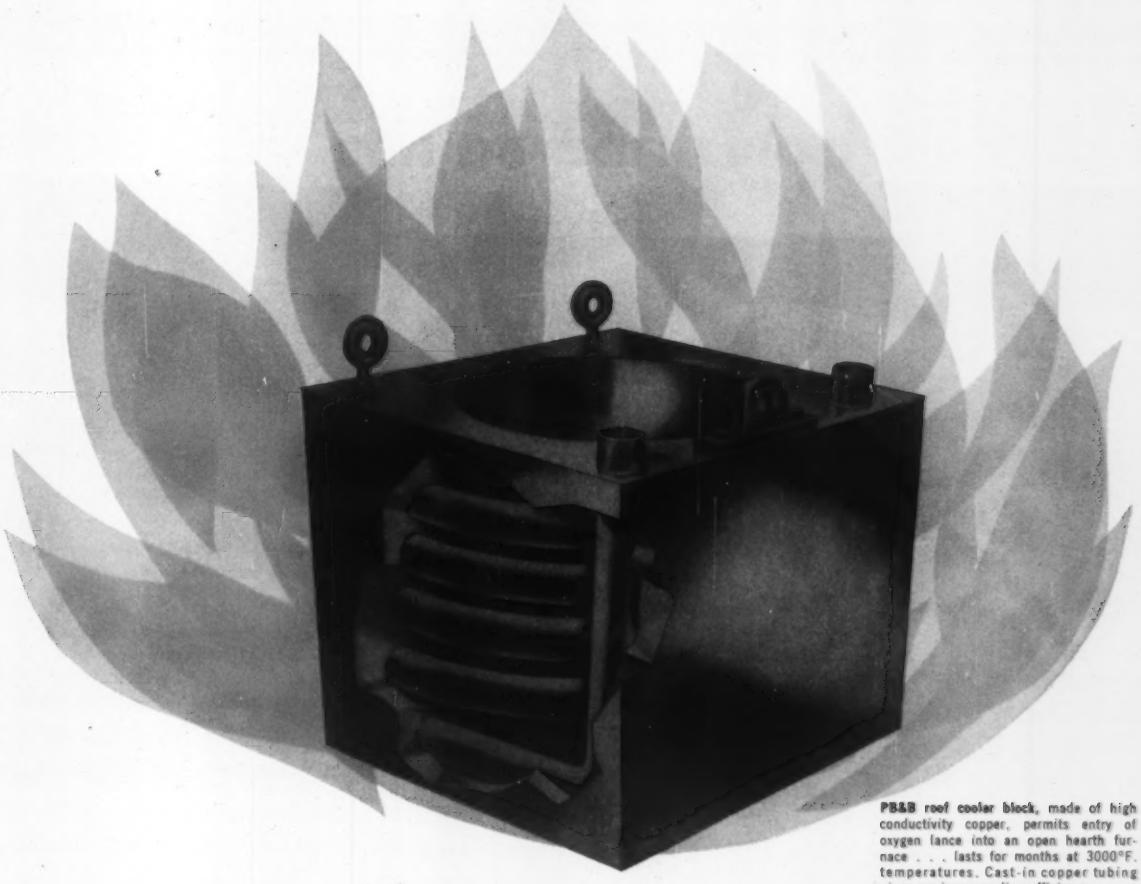
by H. S. Schaufus*

Hot, warm and cold working methods have been used successfully to fabricate high purity vanadium metal into various mill products. For example, ingots measuring up to 6 in. in dia have been reduced by hot working into round bars ranging in size from 3 to ⅜ in. in dia and into flat bars from ¾ to ⅜ in. in thickness by 5½ in. wide.

Hot working poses a major problem

But hot working in the temperature range 1800 to 2300 F poses a

*The author is chief metallurgical engineer at Vanadium Corp. of America.



PB&B roof cooler block, made of high conductivity copper, permits entry of oxygen lance into an open hearth furnace . . . lasts for months at 3000°F. temperatures. Cast-in copper tubing gives maximum cooling efficiency.

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At temperatures where most metals soften or melt, high conductivity copper often can outlast other materials. But—it takes special techniques to make copper live in extreme heat. We have a wealth of experience in this field; here's what we can do for you when you need cast or forged copper components for high temperature duty.

MAXIMUM COOLING IS ESSENTIAL. We have developed methods for casting copper cooling tubing in place in high conductivity copper, to obtain maximum heat transfer.

HIGHEST CONDUCTIVITY COPPER. All copper is not alike: most copper castings have a conductivity of less than 70%, sometimes going as low as 25%, and do not give efficient heat transfer. For castings, we use virgin electrolytic copper guaranteed at least 90% IACS conductivity. Our forgings are made of OFHC* copper, and are guaranteed at least 98% IACS conductivity. Where high strength as well as conductivity is required, we supply alloys of copper . . . chrome, beryllium, zirconium . . . in castings and forgings.

PROCESSING AND TESTING. Our castings and forgings are processed using special techniques developed by us to assure highest possible conductivity. Every piece is checked on a magnatester and its conductivity is individually certified.

We will welcome the opportunity to discuss how high conductivity alloys . . . produced the PB&B way . . . can solve your high temperature problems. Call or write for a consultation.

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HIGH NICKEL ALLOY CASTINGS AND FORGINGS

Call on us for high quality, prompt delivery on castings and forgings of high nickel alloys for extreme temperature service:

Monel**, nickel, cupro-nickel, K Monel**, Inconel**, nuclear quality Inconel.

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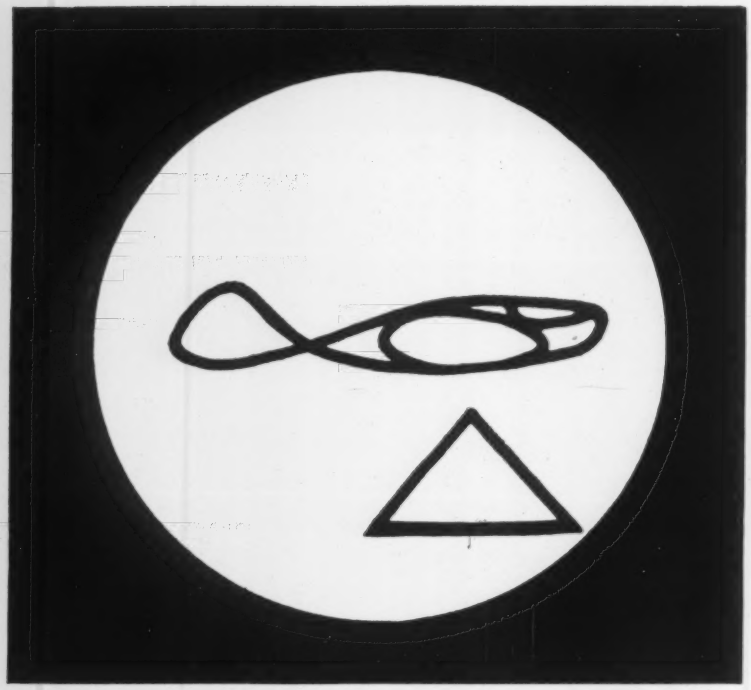

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ENGINEERING & DESIGN

1—Photomicrograph of contaminated vanadium metal surface.

major problem since vanadium oxidizes readily at temperatures above 1200 F, forming a surface skin. This surface skin has a Rockwell hardness of C60 or higher at room temperature.

Accordingly, warm working in the temperature range 700 to 1000 F will probably find greater use in fabricating vanadium. It eliminates exposure of the metal to harmful contamination while permitting very substantial reductions.

Fig 1 shows a photomicrograph of a contaminated vanadium metal surface. It represents a section of a bar that has been hot worked at about 2100 F. Although the original ingot has been completely machined-turned to remove all surface contamination and then heated in a pure argon atmosphere, subsequent exposure to air during hot working rapidly formed a new surface skin.

Studies show that the absorption of oxygen into the metal during exposure to air results in the formation of hard oxides and nitrides on its surface. Exposure of the metal to oxygen alone results in extremely high hardening.

Surface contamination can be kept to a minimum

The depth of surface contamination can be kept to a minimum by

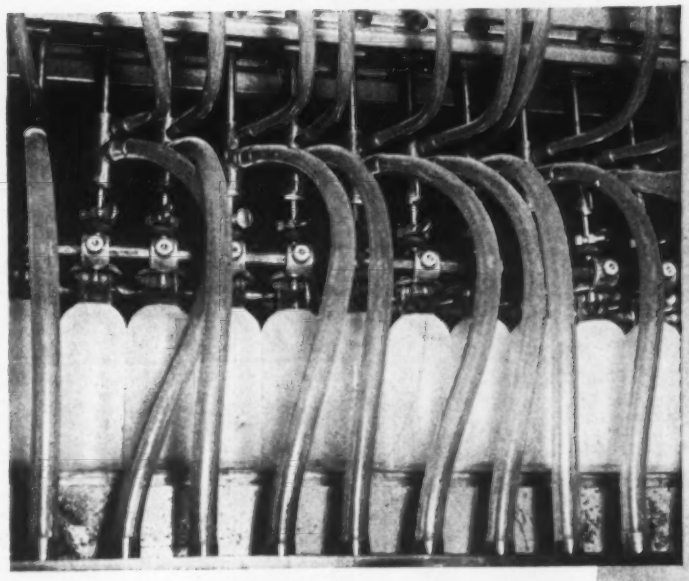
PROPERTIES OF AS-CAST VANADIUM

Tensile Strength, psi	54,000
Yield Strength, psi	45,000
Elongation (in 2 in.), %	12.0
Reduction of Area, %	18.0

[a]Tests performed on specimens measuring 0.505 in. in dia by 2 in. long.

TYGON® *plastic* TUBING

can be particularly helpful



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Tough, flexible Tygon plastic Tubing is resistant to an extremely broad range of corrosive gases and chemicals. In fact, it is the standard tubing in laboratories throughout the world, handling virtually all chemicals normally encountered. Clear as glass, it provides perfect visibility of flow.

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Flexible as a piece of string, available in continuous lengths, Tygon Tubing requires few joints or couplings, is quickly installed in minimum space. Its highly-polished bore provides outstanding flow characteristics, prevents interior build-up, permits simple flush-cleaning. Non-aging and physically tough, Tygon retains its unique combination of advantages throughout a long, trouble-free service life.

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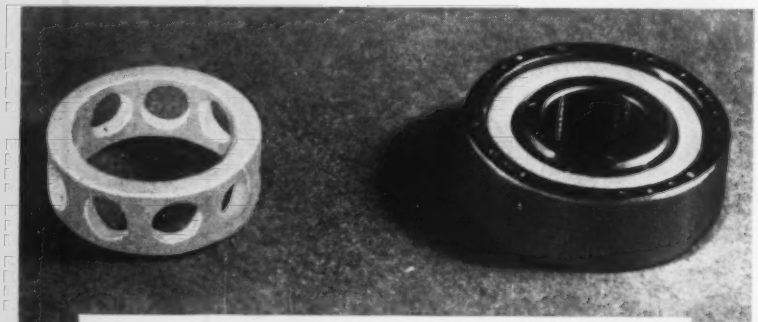
Oil-filled **NYLASINT**® parts retain lubricant while spinning at 1000 Gs



Ball bearing retainers of oil-filled "micro-porous" Nylasint will not bleed under extremes of temperature, pressure and acceleration.

These permanent built-in lubrication properties of Nylasint sintered nylon were demonstrated on ball bearing retainers (above) which operated over 10,000 hours under severe load conditions with no additional lubrication . . . and without loss in performance.

Micro-porous Nylasint parts absorb and retain fluids up to 50% by weight to minimize friction in bearing and wear applications. Almost 20% of the initial oil is retained at 15,000 Gs.

As an ink-filled roller, Nylasint has all the desirable mechanical surface characteristics of nylon while holding a large amount of ink which can be fed uniformly.

Inert fillers also can give resilient Nylasint parts outstanding dimensional stability and high load capacity . . . important for such diverse fields as missile components and steel office furniture.

For complete technical data on Nylasint, call or write for new Nylasint Bulletin BR-1111.

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ENGINEERING & DESIGN

EFFECT OF ANNEALING ON PROPERTIES OF VANADIUM METAL

Type	Sheet (cold rolled)	Wire (cold drawn)
BEFORE ANNEALING		
Ten Str, 1000 psi	120	132
Yld Str, 1000 psi	113	111
Elong (in 2 in.), %	2.0	7.0
Red. of Area, %	41.0	77.0
AFTER ANNEALING*		
Ten Str, 1000 psi	78	78
Yld Str, 1000 psi	66	67
Elong (in 2 in.), %	20.0	25.0
Red. of Area, %	53.0	88.0

*Sheet and wire vacuum annealed 5 min at 1550 F.

the largest possible and most rapid deformation. Surface contamination usually varies from 0.005 to 0.025 in. However, its complete removal is essential for successful processing.

Metal should be kept straight in hot working

In hot working vanadium, it is necessary to keep the metal as straight as possible to obtain the highest metal yield during subsequent machining or grinding operations.

This is particularly important from an economic point of view since contaminated skin metal is unsuitable for remelting.

Small diameter bars and rods (¾ in. in dia or less) can be warm straightened in the temperature range 700-1100 F.

Hot worked vanadium must be machined or ground

After hot working, vanadium metal must be further fabricated by machining or grinding to remove the hard surface skin.

Machining—Cutting action should be started in the soft portion of the metal under the skin, i. e., by lifting the skin with the least amount of tool contact. Determining the skin depth is an important step prior to machining because this indicates proper tool setup, best tool performance, and minimum metal loss.

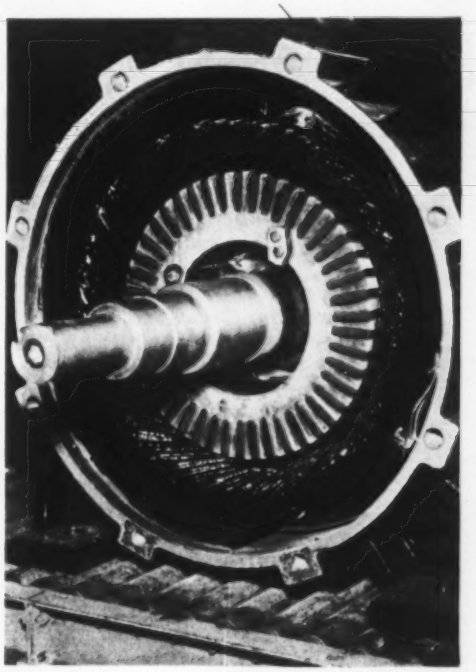
Grinding—Surface grinding requires a great deal more care than machining because of the hard, brittle surface of the metal. Abrasive wheels must be carefully selected and pressures and speeds closely controlled. Also, constant wet flushing with a water soluble oil or other

Copper Alloy Bulletin

BRIDGEPORT BRASS COMPANY

Bridgeport "CONTACT BRONZE"
Cuts Costs of Electrical Spring Contacts by 25%

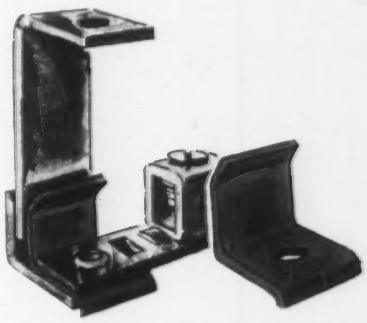
This outstanding Bridgeport alloy offers many of the superior mechanical qualities of phosphor bronze at considerably less cost... with a superior electrical conductivity rated at 22% IACS at 68° soft. Designed to meet the exacting standards of the electronics industry, Bridgeport "Contact Bronze" (Alloy 92) maintains spring properties even after difficult forming operations. Add corrosion resistance and "Contact Bronze" is a guarantee of efficient and reliable performance throughout your product's service life. Here are a few examples:



ELECTRIC MOTORS

The 100-hp 4-pole motors driving extruder-type machines in a dog-food plant were causing frequent production breakdowns. The material processed was so highly viscous that the motors were stalling, jogging and burning out. To meet the high torque, high slip necessary to minimize stalls and also to provide the high thermal capacity required, Allis-Chalmers Company designed a special motor rotor utilizing Bridgeport "Contact Bronze" in place of copper. Burnouts from overload were eliminated and the performance of the "Contact Bronze" motor was so excellent that Allis-Chalmers received an order for another sixteen of the same type.

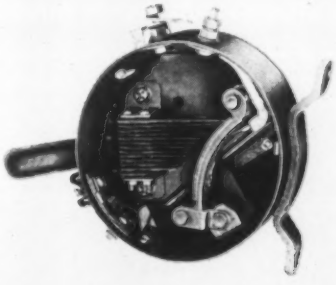
PRESSURE CLIPS



American Electric Switch Division, Clark Controller Company, found that "Contact Bronze" fitted their needs for a lower cost alloy for pressure clips. Its electrical conductivity, corrosion resistance, spring and formability properties were more than comparable with other alloys... at 25% less cost.

TRAILER TRUCK BRAKING SYSTEM

Warner Electric Brake & Clutch Company manufactures an ingenious electric brake system for heavy-duty trailer trucks. Through a graduated series of Bridgeport "Contact Bronze" leaves, it allows the driver to adjust torque instantly and smoothly to suit load and road conditions. The conductivity and performance-proved spring properties of "Contact Bronze" provide added safety and long-haul reliability.



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Electronic and mechanical devices, switch gears, circuit breakers, contacts, terminals are just a few of the applications. There are thousands of others. Call your nearest Bridgeport Sales Office or write Dept. 3509 for full details of Bridgeport Contact Bronze. Bridgeport Brass Company, Bridgeport 2, Conn.

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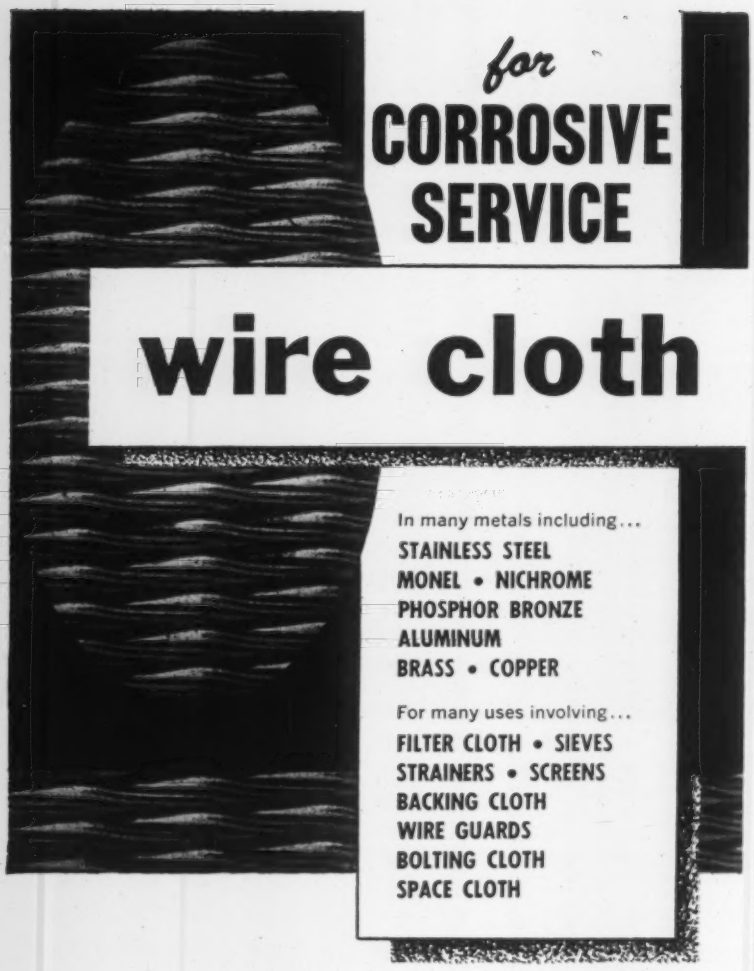

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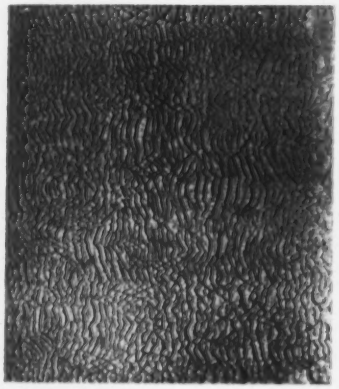

2 — Surface of vanadium metal cracks if it is not ground under carefully controlled conditions.

coolant is required. If these precautions are overlooked, cracking will result because of excessive local heating and expansion, particularly at the grain boundaries of the metal (see Fig 2).

Surface conditioning—Shot and sand blasting have been found ineffective for surface conditioning hot worked vanadium because of the metal's extremely hard surface skin. Preliminary steps have been taken to investigate other methods of surface conditioning.

Cold working

Final processing of many vanadium products requires cold working. The metal can be cold rolled into sheets, strip and foil, cold drawn into wire and tubing, and cold formed into various other shapes.

Single reductions up to 30% of cross section have been obtained by cold working. However, reductions from 5 to 10% of cross section are favored, chiefly to avoid loss of metal.

Recrystallization

It has been found that severely distorted hot, warm or cold worked vanadium structures will respond

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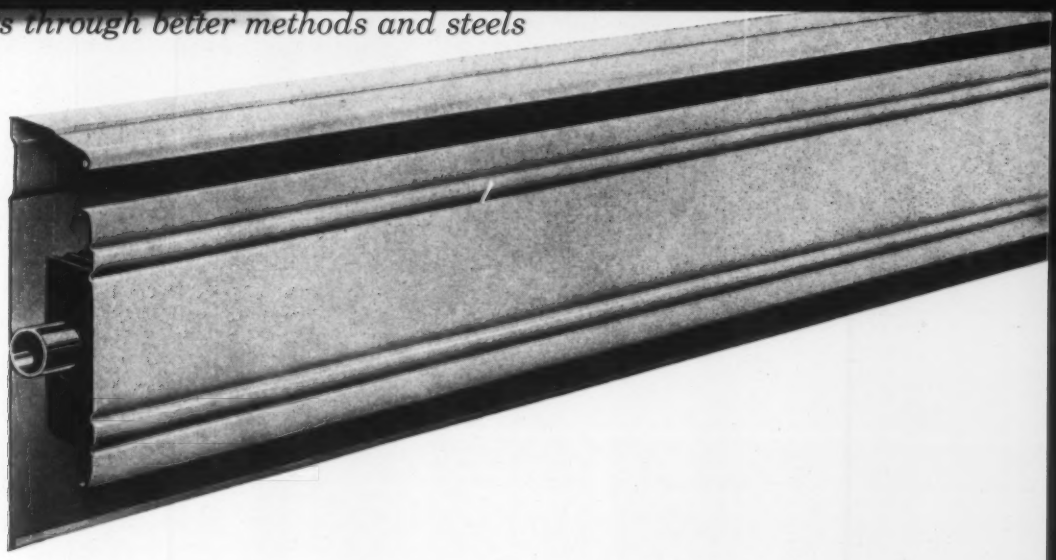

With Weirzin: easy fabrication of beautiful baseboard heating panels that last and last and last.

This high quality electrolytic zinc-coated and bonderized steel sheet is produced to our customers' requirements for uniformity of gage, width and temper. This attention to quality along with the excellent corrosion resistance provided by the zinc coating puts Weirzin at the top of its category and around the bottom of an increasingly large number of commercial and residential interiors.

There, these baseboard heating panels provide a functional border of beauty that requires little or no maintenance. The chemically treated surface holds the smoothest of paint jobs and the tight zinc steel bond eliminates all possibility of underfilm corrosion. Proof that despite the severe bending and forming it undergoes, Weirzin maintains a flawless bond between the zinc coating and the steel sheet.

Result? The fabricator enjoys the workability of a fine product and the ultimate consumer benefits from its serviceable beauty. And that's true of any product made from Weirzin.

Strong, smooth Weirzin electrolytic zinc-coated steel is manufactured by Weirton Steel Company. Its high quality is typical of the many other steels produced by Weirton and used throughout industry to improve products, methods and profits.

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WEIRTON STEEL
Weirton, West Virginia

WEIRTON STEEL COMPANY

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The wafer-thin part shown here is a spring contact blade that forms an integral part of an automatic starting and reversing switch used on all models of garbage disposers produced by In-Sink-Erator Manufacturing Company of Racine, Wisconsin. Continued exploration of ways to cut the cost of manufacture—hence deliver a better product for less money—led In-Sink-Erator's design people to Miller, whose on-the-spot metallurgical specialists were able to recommend Grade C 200-PLUS phosphor bronze, a material with equal performance to the beryllium copper previously used . . . yet at far less cost. If cost-cutting has a place in *your* operation, a Miller specialist can be at your plant in hours to tell you how!

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. . . WHERE PHOSPHOR BRONZE IS THE MAIN LINE—NOT A SIDELINE

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well to annealing at temperatures from 1500 to 1900 F. Such treatments must be done in a vacuum or in an inert atmosphere to avoid surface contamination.

Polyethylene Shields Against Radiation

The use of Type III higher density polyethylene in neutron shielding is currently aiding in the advancement of nuclear propelled aircraft and ships, says D. E. Setter of Phillips Chemical Co., Bartlesville, Okla.

Reason: high density polyethylene slows down neutrons, withstands the damaging effects of continued irradiation, and is tough and lightweight.

Polyethylene better than water, concrete

Setter, who presented a paper on "Neutron Shielding with Linear Polyethylene" at the 16th annual meeting of the Society of Plastics Engineers, Inc. in Chicago early this year, says neutron shielding efficiency of high density polyethylene is considerably better than that of water or concrete.

High density polyethylene, he says, has the highest concentration of hydrogen atoms (8.2×10^{22} atoms per cu cm) among plastics and other usable materials. Fast neutrons are slowed down by elastic collisions with protons in the hydrogen atoms. The neutrons are usually captured by a boron nucleus or similar element that has been incorporated into the polyethylene.

The reaction between a thermal neutron and a boron nucleus creates a low energy alpha particle and some soft gamma energy, both of which have little consequence as radiation hazards.

Setter says linear polyethylene shielding with boron is only good for neutrons. It is not particularly effective against gamma radiation since heavy mass is needed to absorb energy. In some composite shield designs, heavy materials such as lead compounds can be incorporated into high density polyethylene or used in laminar designs to shield against both neutrons and gamma rays.

MR. ENGINEER: **HAVE YOU THOUGHT OF** NATIONAL GRAPHITE?

"National" graphite is available from stock in a wide variety of sizes ranging from minute particles (powder) to five-ton blocks. Recently, National Carbon produced cylindrical stock 61″ in diameter by 72″ long weighing seven tons, rectangular stock 30′ long by 14″ wide by 12″ thick, and slab stock 120″ long by 47″ wide by 20″ thick. Compare these large shapes with minute pieces, many of which will fit in the palm of your hand, and you'll realize the range of sizes available for your design applications.

This high-temperature material with its unusual combination of properties can be supplied either as plain or machined pieces. Whatever your needs, let National Carbon Company quote the job. For details on sizes and grades of graphite available—whether round, square or rectangular—write for CATALOG SECTION S-5950. Address: National Carbon Company, Division of Union Carbide Corporation, 270 Park Avenue, New York 17, N. Y. In Canada: Union Carbide Canada Limited, Toronto.

"National" and "Union Carbide" are registered trade-marks for products of

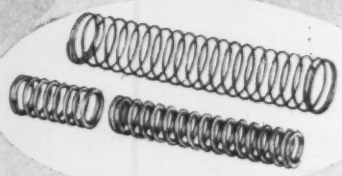
NATIONAL CARBON COMPANY

UNION CARBIDE

For more information, turn to Reader Service card, circle No. 421

Spotlighting Reliability!

MICRO-PROCESSED BERYLLIUM-COPPER I-S SPRINGS

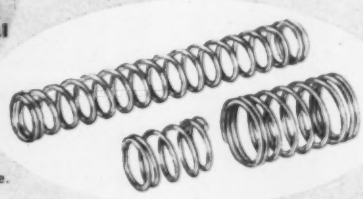


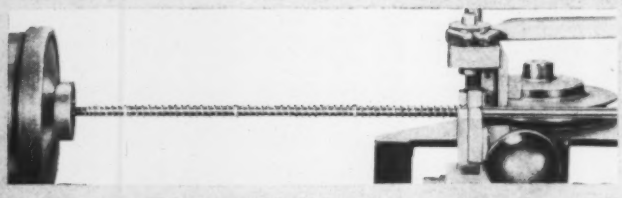
Exclusive Design Advantages

I-S micro-processed beryllium copper springs, designed into control devices, relays, circuit breakers, etc., result in improved performance and lower cost. Their high degree of uniformity eliminates the necessity of hand adjustment during assembly and is your guarantee of uniform performance.

Important Electrical Advantages

I-S micro-processed beryllium copper springs receive laboratory-proven heat treatment, therefore they can operate at higher temperatures and carry more current with less temperature rise.





THE *Ideal* SPRING MATERIAL

Beryllium copper is an ideal spring material because of its natural inherent characteristics. It is non-magnetic, has the corrosion resistance of pure copper, high electrical conductivity, high wear resistance and a high endurance life. The temperature used to develop spring temper also serves to relieve internal stresses remaining from cold work. The ability to conform to jigs and holding fixtures during heat-treatment makes it particularly well suited for our specially designed, patented machines. The wire is placed upon the mandrel in an exacting manner, strictly in accordance with the engineered design. The springs are set to this design by heat-treatment while they are still on the mandrel. There is no spring back upon removal from the mandrel with the result that the springs are uniform, stable and free from drift.

CALL OR WRITE FOR THE I-S CATALOG covering in detail compression springs, flat springs, strip springs, contact rings, contact strips and screw machine products.

IN SWEET'S PRODUCT DESIGN FILE

INSTRUMENT SPECIALTIES CO • INC

224 BERGEN BLVD. "MICRO---PROCESSED" I-S BERYLLIUM COPPER SPRINGS LITTLE FALLS, N. J.

Telephone: CLifford 6-3500

For more information, turn to Reader Service card, circle No. 392

TECHNICAL LITERATURE

(cont'd from p 53)

Books

Materials Selection for Process Plants. *R. E. Grackenback. Reinhold Publishing Corp., New York. 1960. Cloth, 6 by 9 in., 328 pp. Price $8.50*

Provides the latest information on design, fabrication and installation of process equipment. The book is mainly concerned with the selection of a proper material for the environment in which it will be used. The book discusses the major metals, plastics, elastomers, coatings and cements, and gives data on their composition, physical and mechanical properties, fabrication, chemical resistance and applications.

ASTM Standards on Materials. *American Society for Testing Materials, Philadelphia.*

Compilation of Standards on Plastics: 11th Edition. *1960. Cloth, 6 by 9 in., 1242 pp. Price $9*

Specifications for molding compounds and materials; mechanical, thermal and optical properties of plastics; standard and molded shapes; effects of radiation on plastics; analytical methods for plastics; electrical insulating materials; rubber and rubber-like materials; adhesives; and definitions and nomenclature of plastics.

Tentative Reference Radiographs for Inspection of Aluminum and Magnesium Castings: Series II E155. *Price $125*

Provides 13 radiographs covering discontinuities in aluminum alloy castings, and 12 for magnesium alloy castings. Each radiograph illustrates eight grades of severity for a particular discontinuity.

1959 Supplements to Book of ASTM Standards. *1959. Paper, 6 by 9 in. Price $4 per volume, $40 per set*

PART 1: FERROUS METAL SPECIFICATIONS. *562 pp.*

PART 2: NON-FERROUS METALS SPECIFICATIONS AND ELECTRONIC MATERIALS. *280 pp.*

PART 3: METHODS OF TESTING METALS (EXCEPT CHEMICAL ANALYSIS). *110 pp.*

PART 4: CEMENT, CONCRETE, MORTARS, ROAD MATERIALS, WATERPROOFING, SOILS. *200 pp.*

PART 5: MASONRY PRODUCTS, CERAMICS, THERMAL INSULATION, ACOUSTICAL MATERIALS, SANDWICH AND BUILDING CONSTRUCTION, FIRE TESTS. *218 pp.*

PART 6: WOOD, PAPER, SHIPPING CONTAINERS, ADHESIVES, CELLULOSE, LEATHER, CASEIN. *142 pp.*

PART 7: PETROLEUM PRODUCTS, LUBRICANTS, TANK MEASUREMENT, ENGINE TESTS. *428 pp.*

PART 8: PAINT, NAVAL STORES, AROMATIC HYDROCARBONS, GASEOUS FUELS, ENGINE ANTIFREEZES. *252 pp.*

PART 9: PLASTICS, ELECTRICAL INSULATION, RUBBER, CARBON BLACK. *546 pp.*

PART 10: TEXTILES, SOAP, WATER, ATMOSPHERIC ANALYSIS, WAX POLISHES. *394 pp.*

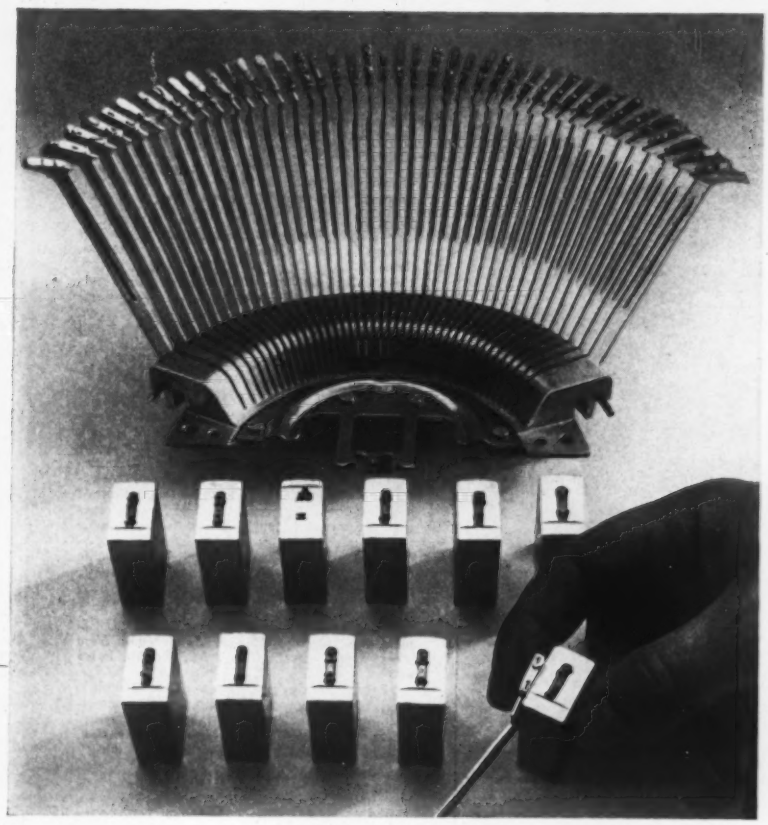
Compilation of Standards on Rubber Products: 19th Edition. *1960. Cloth, 6 by 9 in., 1052 pp. Price $9.75*

Standards covering urethane foam, packing and gasket materials, tapes, hard rubber, latex foam, sponge and expanded cellu-

Tool Steel Topics

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Export Distributors: Bethlehem Steel Export Corporation



IBM makes 200 per cent more type slugs per matrix with Bearcat Tool Steel

Talk about enthusiasm! At the Lexington, Ky., plant of International Business Machines Corp. they have good reason to sing the praises of Bearcat tool steel. Recently, production of type slugs per matrix was improved 200 per cent by changing to a die made of Bearcat. The die "kneads" raised letters of the alphabet into steel slugs.

Bearcat is best known for its remarkable shock-resistance. In this instance, the manufacturer also reported better resistance to wear, and easier machinability (as compared with the tool steel formerly used).

Bearcat is our super grade of shock-resistant air-hardening tool steel. It's ready and willing to handle the toughest shock applications. Because it's an air-hardening steel, Bearcat minimizes both quenching hazards and distortion in heat-treatment.

Like to try Bearcat? Telephone your Bethlehem tool steel distributor.

BETHLEHEM TOOL STEEL ENGINEER SAYS:

TOOLS can be repaired by welding if the proper procedure is used

To incorporate design changes or repair, all tools and dies made of tool steel can be welded successfully if the following procedure is observed:

1. Full-anneal the tools. Good atmosphere control is necessary to avoid scaling and decarburization of the working surfaces.

2. Prepare the crack for welding by "veeing" its full depth and length. Magnetic particle inspection is advisable.

3. Use a welding rod which will deposit steel of the same composition as the tool.

4. Preheat to 400 F - 800 F, and maintain this temperature during welding.

5. Clean the slag from each bead before proceeding with the next bead.

6. Immediately after welding, transfer the tool into a warm furnace (400 F min) and full-anneal.

7. Machine or grind the weld to the desired tool dimensions.

8. Heat-treat the tool by quenching and tempering to the desired hardness, using the standard procedure for the grade involved.

9. Grind the tool working surfaces. The depth of metal removal will depend upon the amount of decarburization produced in Steps 1, 6, and 8.

The use of this procedure will permit the successful welding of tools if it is essential that welding be done. In the majority of instances, however, it will be found both cheaper and quicker to make up new tools.

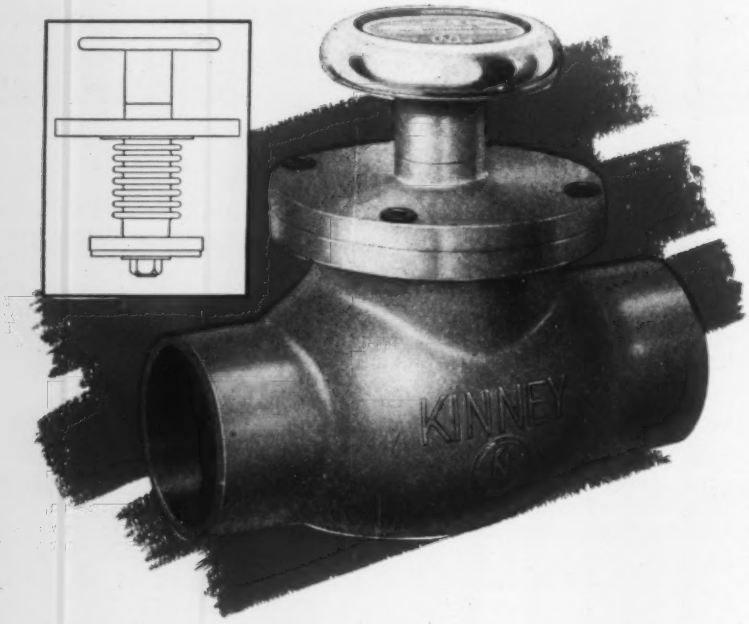
When emergency welding is done on a production line, it is often necessary to eliminate many of the steps mentioned above, thereby reducing the chances of producing successful welds.

For more information, turn to Reader Service card, circle No. 338

Kinney®

BBSM VACUUM VALVES

say, "STOP" and "GO" and Mean It!



The new Series BBSM KINNEY Vacuum Valves form a reliable force of "Traffic Cops" for your Vacuum systems. In sizes 1", 1½", 2" and 3", these Bronze Bellows Sweat Fitted Valves are especially designed for Vacuum applications having soldered or brazed manifolding. They are of the globe type with non-rising stem, with positive isolation of rotating parts. The brass bellows is sealed to the seat disc and bonnet flange by static "O" rings of Buna N.

Assembly of KINNEY BBSM Valves into the Vacuum system is supremely simple. Removal of stem, cover and bellows assembly as a unit from the body of the Valve is accomplished by unscrewing four cap screws – thus replacement of bellows is no problem. Each KINNEY BBSM Valve is mass spectrometer leak tested to assure vacuum tightness.

KINNEY VACUUM DIVISION
THE NEW YORK AIR BRAKE COMPANY
3523J WASHINGTON STREET • BOSTON 30 • MASS.

WRITE FOR CATALOG BULLETIN NO. 3421.1A TODAY!

Please send me Bulletins 3421.1A and 3421.3 giving full information and prices on KINNEY BBSM Vacuum Valves.

Name_____
Company_____
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City_____ Zone____ State_____

For more information, turn to Reader Service card, circle No. 399

TECHNICAL LITERATURE

lar rubber, synthetic elastomers and compounding materials. Information also on chemical, physical, electrical and weathering tests for rubber.

ASTM Standards on Electrical Insulating Liquids and Gases. *1960. Cloth, 6 by 9 in., 336 pp. Price $4.25*

Compilation of ASTM Standards on Metallic Electrical Conductors. *1960. Cloth, 6 by 9 in., 368 pp. Price $4.50*

Contains 59 standards covering aluminum-coated steel wire, copper-covered steel, aluminum, and galvanized steel and iron.

ASTM Standards on Light Metals and Alloys. *1960. Cloth, 6 by 9 in., 368 pp. Price $4.50*

Contains recommended practices, methods of test and specifications covering aluminum and magnesium ingots, castings, bars, rods, wire shapes, forgings, pipe, tubes and wrought products.

Metallizing of Plastics. *H. Narcus. Reinhold Publishing Corp., New York. 1960. Cloth, 5 by 7 in., 215 pp. Price $5.50*

Describes production procedures, formulations, and techniques for all known metallizing methods. These include deposition of metallic coatings by chemical reduction, vacuum metallizing, cathode sputtering, spray and electrodeposition. The book also discusses characteristics and testing of metallic deposits on plastics, recent developments, and potential uses for metallized plastics.

Applications of Thermoelectricity. *H. J. Goldsmid. John Wiley & Sons, Inc., New York. 1960. Cloth, 4 by 7 in., 126 pp. Price $2.25*

Thermoelectric properties of semiconductors, preparation and evaluation of materials, semiconductor alloys, theory of thermoelectric devices, thermoelectric generation, and applications of the Peltier effect.

Semiconductor Abstracts: Volume 5. *Compiled by members of Battelle Memorial Institute. John Wiley & Sons, Inc., New York. 1960. Cloth, 8½ by 11 in., 450 pp. Price $12.*

Abstracts on elemental and compound semiconductors, theory, and applications.

Metal Statistics: 1960. *American Metal Market, New York. 1960. Cloth, 4 by 6 in., 830 pp. Price $3.50.*

Price, production and consumption information on ferrous and nonferrous metals.

Transactions of the 1959 Vacuum Metallurgy Conference. *Edited by R. F. Bunshah. New York University Press, New York. 1960. Paper, 8½ by 11 in., 220 pp. Price $7.50*

Contains 22 papers that give information on vacuum arc melting and casting, vacuum degassing, vacuum investment casting, applications of vacuum metallurgy, electron beam techniques in vacuum metallurgy, and vacuum induction melting.

Handbook of Geophysics: Revised Edition. *Macmillan Co., New York. 1960. Cloth, 8½ by 11 in., 680 pp. Price $15*

Although the subject matter of this book is concerned primarily with various environments, the book should be of interest to designers and materials people because it provides a valuable source of information on environments that may be encountered by

ECONOMY, DURABILITY AND DEPENDABILITY are outstanding characteristics of these sintered metal gears. Parts like these are the result of close cooperation between Delco Moraine and its customers from idea through design and development to production.

DELCO MORAINE

DEPENDABLY MADE parts for industrial progress • Division of General Motors, Dayton, Ohio

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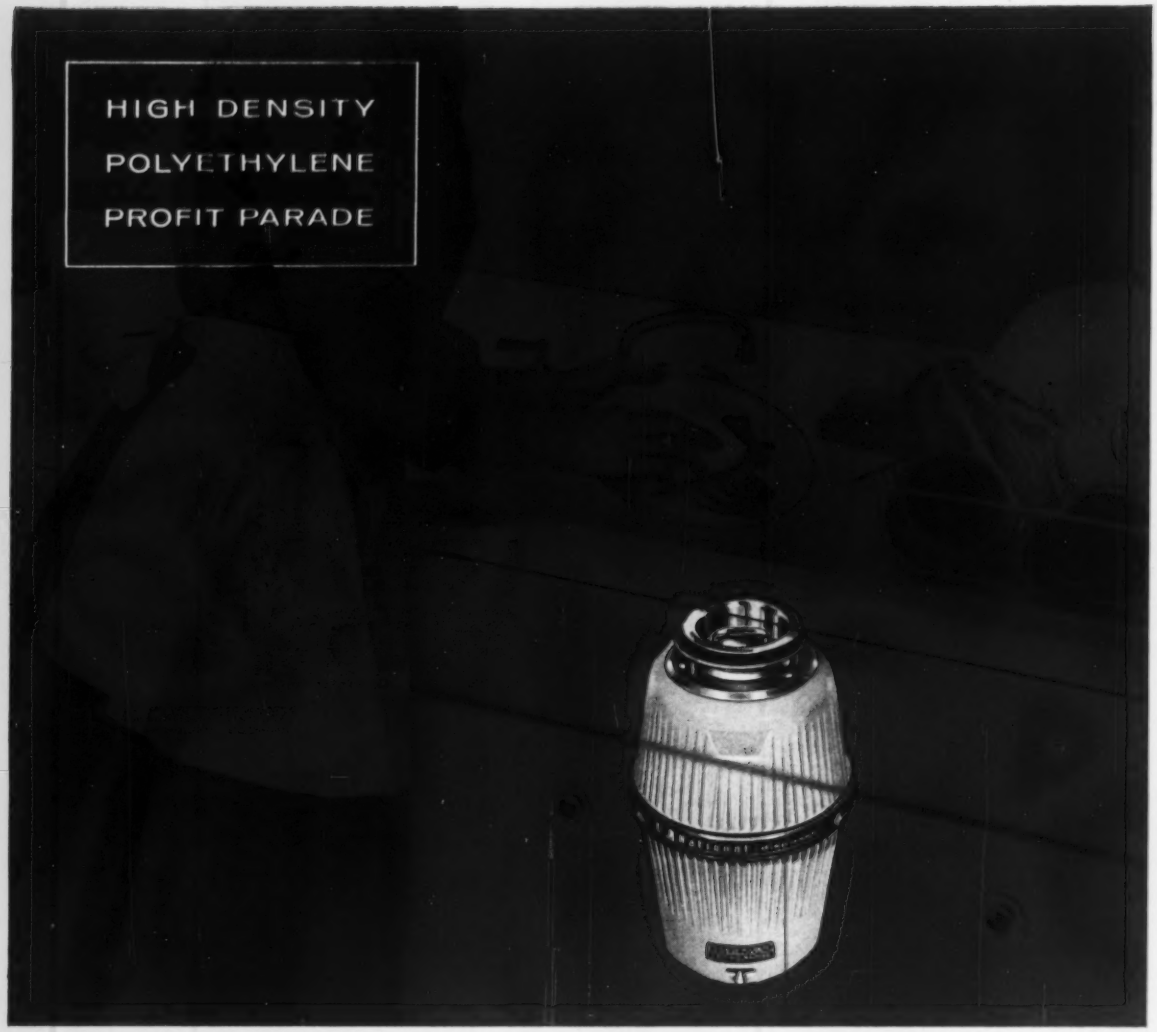


Grace Plastic Upgrades New Appliance Model

The new Citation Model National Disposer shows how the use of Grex high density polyethylene results in upgrading a product to increase its consumer appeal.

Made by the Plumbing Equipment Division of National Rubber Machinery Company, the appliance grinds food wastes into micro-sized particles that wash down the drain. Its primary appeal is freedom from garbage-handling chores. Three additional sales-stimulating features are direct results of specifying Grex for the housing:

1. Freedom of design due to the moldability of the Grace plastic provides clean, fresh styling.

2. A choice of attractive colors is offered. Colors are molded into the Grex housing—can't peel, chip or fade.

3. The plastic's sound-deadening properties are utilized to help make the Disposer operate "whisper quiet."

In addition to these features, the housing is strong, rigid and virtually indestructible. It cannot rust, is unaffected by chemicals normally corrosive to other materials and withstands the high temperature of boiling water.

If you are looking for ways to upgrade your product it will pay you to find out exactly what high density polyethylene has to offer by calling in the experts. Grace has the production, technical, and marketing facilities to help put your product in the Grex profit parade. Everyone says we're easy to do business with.

Grex is the trademark for W. R. Grace & Co.'s Polyolefins.

W.R. GRACE & CO.
POLYMER CHEMICALS DIVISION CLIFTON, NEW JERSEY

For more information, turn to Reader Service card, circle No. 381

What are the advantages of using Grex to make a product prototype?

The prototype for the new model National Food Waste Disposer shown here was vacuum formed from Grex sheet in our Clifton Laboratories. Whenever possible, prototypes of products designed for production with high density polyethylene should be made of the same material. This is the best way to see how the product will look and feel before costly molds are built and production actually started.

Helpful in marketing. Although most prototypes are required from an engineering standpoint they are often useful to guide marketing decisions as well. This was the case with the Grex prototype of the National Disposer. The object was to determine, in advance of production, how the trade would react to the new model by presenting prototypes or samples that come as close as possible to the finished product.

Grace's part. Working from the manufacturer's engineering drawings Grace designed wooden molds and vacuum formed a number of samples from Grex sheet. The samples were sent to the manufacturer for finishing (trimming of flash and drilling the necessary holes), and returned to Clifton for surface finishing. The samples were completed in time for display at an important trade show. Trade reaction was highly favorable, just as you would expect from reading about the product on the opposite page.

You are invited to take advantage of Grace technical service. Perhaps we can help you by making a Grex prototype for your high density polyethylene application. Or perhaps you need assistance on other aspects of design or production of high density polyethylene parts. If so, now is the time to contact:

Technical Service Department
W. R. Grace & Co., Clifton, New Jersey

TECHNICAL LITERATURE

materials used in rockets, missiles and spacecraft.

The various chapters discuss atmospheric density, wind, temperature, thermal radiation, cosmic radiation, meteors, precipitation, clouds and geomagnetism. Each chapter is documented with detailed tables and graphs.

Progress in Semiconductors: Volume 4. *Edited by A. F. Gibson, F. A. Kroger and R. E. Burgess. John Wiley & Sons, Inc., New York. 1960. Cloth, 6 by 9 in., 296 pp. Price $10.50*

Subjects covered include: 1) negative effective masses in semiconductors; 2) oxidation phenomena on germanium surfaces; 3) theory of avalanche multiplication in nonpolar semiconductors; 4) internal field emission; 5) noise in semiconductors; 6) electrical effects of dislocations in semiconductors; 7) dielectric properties of solids in relation to imperfections; and 8) non-crystalline, amorphous and liquid electronic semiconductors.

Reports

Technical translations. Here, as a special service, is a partial list of agencies that supply translations of technical articles from foreign language journals.

Associated Technical Services, Inc., *P. O. Box 271, East Orange, N. J.* Translations of technical papers from French, German, Italian, Russian, Chinese, Arabic and other languages. Price $1.75 to $4.00 per 100 words of the English version.

Henry Brutcher, *P. O. Box 157, Altadena, Calif.* Said to have one of the largest collections of translated metallurgical data in existence. Three by five index cards give abstracts of technical papers translated from Russian, German and other languages. Price 2¢ per card.

Columbia Technical Translations, *5 Vermont Ave., White Plains, N. Y.* Cover-to-cover translation of the monthly magazine *Bulletin of the Academy of Sciences of the USSR —Physical Series* which publishes articles on ferromagnetism, piezoelectricity, ferrites, etc. Price $20 per issue, $215 per year.

Consultants Bureau Enterprises, Inc., *227 W. 17th St., New York 11.* Cover-to-cover translations of 37 Russian technical journals. Prices on request.

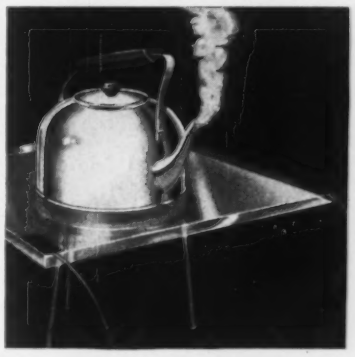
Morris D. Friedman, Inc., *P. O. Box 35, West Newton 65, Mass.* Translations of table of contents of current foreign language technical journals from which full translations can be ordered. Price $1.

(continued on p 212)

LOF GLASS

Notes on
VACUUM-DEPOSITED COATINGS

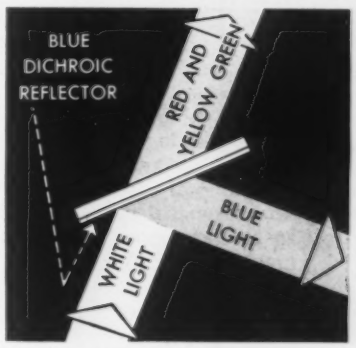
Transparent coating makes a heating unit of a piece of glass



Among vacuum-deposited coatings by Liberty Mirror is a transparent electric conductor that acts as a resistance heating element on glass.

The coating is used to defog or de-ice optical surfaces and instrument faces, camera windows, prisms, lenses and other optical elements.

Coatings put light and heat to work on new product design

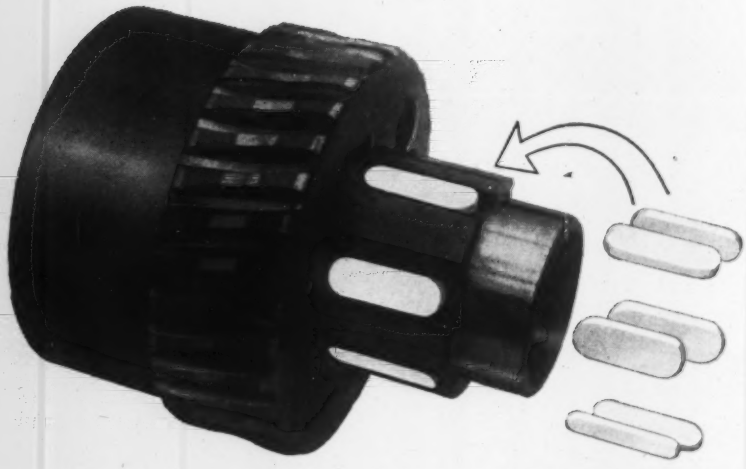


Another valuable contribution by vacuum-deposited coatings is to make aluminum or gold first-surface mirrors, neutral filters, transparent mirrors, high-efficiency beam splitters, beam-splitting dichroic mirrors and filters.

Applied to glass, metal or plastic, vacuum-deposited coatings are used in such varied products as toys, pin setters, wheel-aligning equipment, aircraft and missiles.

A reference file is available on characteristics and durability of each coating. Liberty Mirror engineers will help you solve application problems. Write Liberty Mirror Div., Libbey-Owens-Ford Glass Co., 811 Madison Avenue, Toledo 1, Ohio.

For more information, circle No. 407



Roll clutch cam section of automatic screw machine. Six inserts of Kennametal Grade K92 are used at point of great impact.

In roll clutch cam section . . .

KENNAMETAL* Grade K92 inserts outlast steel 8 to 1

Carburized and case-hardened *steel* inserts used at a point of great impact on an automatic screw machine were averaging 3.5 months' service. Replacing the inserts was a 4-to-5 hour job for the machine user.

Then, 29 months ago, the manufacturer installed a set of *Kennametal* tungsten carbide inserts on a machine as a test. The first set installed is still going strong, and has eliminated more than 30 hours' downtime.

Recognizing how much customers would welcome this outstanding decrease in maintenance, this customer now uses Kennametal inserts as original equipment and replacement service parts for this model. In addition, plans have been made to extend the use of Kennametal for wear parts on other machines they manufacture.

The Kennametal family of hard carbide compositions contains many different grades. In this application, Kennametal Grade K92 was selected for its medium hardness (87.5 RA) and high transverse rupture strength (385,000 psi). Chances are K92, or one of the other Kennametal Grades, can solve one of *your* machine design problems. Why not find out more about this metal that has remarkable resistance to impact, abrasion, corrosion, extreme temperatures and pressures. Contact your Kennametal Representative or write us direct for Bulletin B-111-B, "Properties of Kennametal," and Bulletin B-666, "Proven Uses of Kennametal and Kentanium." KENNAMETAL INC., Department MDE, Latrobe, Pennsylvania.

*Kennametal is the registered trademark of a series of hard carbide alloys of tungsten, tungsten-titanium and tantalum. Kentanium is the registered trademark for one of the series that has special advantages for applications requiring a lighter weight material, or maximum resistance to temperature extremes. 33520

INDUSTRY AND **KENNAMETAL** *...Partners in Progress*

For more information, turn to Reader Service card, circle No. 353

TECHNICAL LITERATURE

Literature Service Associates, *Route 1, Bound Brook, N. J.* Full translations and abstracts of foreign language papers that are written primarily for people in the process industries. Prices on request.

Primary Sources, *11 Bleeker St., New York 12.* Cover-to-cover translation of the monthly magazine *Soviet Journal of Non-Ferrous Metals.* Price $95 per year.

Superintendent of Documents, U. S. Government Printing Office, *Washington 25, D. C.* Bi-monthly list and description of translations that are available from Office of Technical Services, Library of Congress and other agencies. Price 60¢ per copy, $12 per year.

Unclassified documents SUBJECT INDEX TO UNCLASSIFIED ASTIA DOCUMENTS. *1960. 2617 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $30 (PB 151567)*

Catalogs 40,000 unclassified documents published by the Armed Services Technical Information Agency (ASTIA).

Solid state abstracts SOLID STATE ABSTRACTS: VOLUME 1. *Cambridge Communications Corp., 238 Main St., Cambridge 42, Mass. Price $25 (journal), $250 (index cards)*

A journal devoted to the theory, production and use of solid state materials and devices (including semiconductors). The abstracts prepared for the journal are also available on 3 by 5 in. index cards.

Preservative brake fluid DEVELOPMENT OF AN OPERATIONAL PRESERVATIVE HYDRAULIC BRAKE FLUID. *C. B. Jordan, Aberdeen Proving Ground. Aug '59. 21 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price 75¢ (PB 161096)*

Information on a preservative brake fluid for automobiles and trucks that has proved successful in storage up to 30 months and in operation to 0 F.

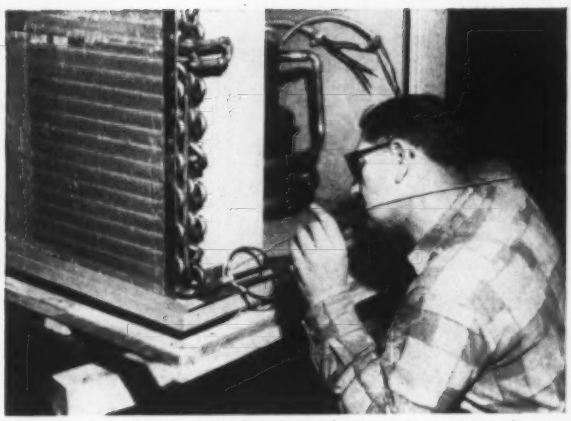
Properties of ceramics PROPERTIES OF HIGH-TEMPERATURE CERAMICS AND CERMETS —ELASTICITY AND DENSITY AT ROOM TEMPERATURE. *S. M. Lang, National Bureau of Standards. Mar '60. 45 pp. Available from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 20¢ (NBS Monograph No. 6)*

Bulk and theoretical densities, and dynamic room temperature elastic constants are given for 20 different materials including oxides, carbides, borides, cermets, and an intermetallic compound.

Rust preventive EMULSIFIABLE AND FIRE RESISTANT RUST PREVENTIVES. *V. Y. S. Hong, Rock Island Arsenal. Apr '59. 72 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $2.25 (PB 161326)*

Describes an emulsifiable rust preventive developed to replace petroleum-base solvent types. According to the report, the experimental product had a maximum pour point of 32 F, a moisture content under 8%, no separation from 0 to 82 F, no gelling between 72 and 82 F, and more than a year's shelf life from 50 to 110 F.

HOW TO MAKE 4,999 JOINTS WITHOUT FAIL



Here, with a double tipped oxyacetylene torch, operator brazes condenser coil joints. This condenser-compressor assembly contains 30 hook-up joints, not counting return bends.

The unit evaporator, located inside the house, contains 36 hand-brazed SIL-FOS 5 joints.

International Heater Does it With HANDY & HARMAN SIL-FOS 5

Production statistics of this manufacturer of heating and air-conditioning equipment show that perhaps one in five thousand hand-brazed joints may need touching up. This is a micrometer measurement away from absolute perfection.

One of the Utica, New York, company's products is a home air conditioner that utilizes the existing duct work of the structure's hot-air furnace. Its novelty lies in the fact that the unit's compressor and condenser are located outside the house for noise-free coolness inside the home.

The unit's evaporator is installed on top of the furnace for simple tie-in to the plant's ducting for hot-weather operation.

Shown here in production is International's Model 5-5B of 5 ton capacity.

This "joint in quantity" record is being duplicated by SIL-FOS 5 silver alloy brazing in the manufacture of heating, air-conditioning and refrigeration equipment everywhere. Its strength, air- and leak-tightness and ease of application are some of the reasons that make Handy & Harman SIL-FOS 5 brazing one of the *surest* metal joiners in existence. We'd like you to know more about SIL-FOS 5 and the job it can do for you in joining copper and copper alloys in any shape, size and complexity. Our Bulletin 20 deals with this in a complete and informative manner. A request to Handy & Harman, 82 Fulton Street, New York City 38 will bring you your copy.

Your No. 1 Source of Supply and Authority on Brazing Alloys

HANDY & HARMAN

General Offices: 82 Fulton St., New York 38, N. Y.

For more information, turn to Reader Service card, circle No. 388

New Ideas in NYLON

More than 10,000 plastic items are warehoused by Cadillac Plastics for its 25,000 customers. Shown above is part of the Cadco® manufactured nylon stock of one of Cadillac's 17 warehouses.

Cadillac Depends On Spencer Nylon To Produce Wide Range Of Stock Shapes

Detroit company makes it easy for designers to take advantage of nylon's low cost and special properties

Now that nylon costs less than many die-cast metals, more and more manufacturers are using this tough, long-wearing plastic to cut costs and improve their products. A unique service offered by Cadillac Plastic and Chemical Company of Detroit makes it easy for designers to convert products to nylon.

Specializing in the production and distribution of stock nylon shapes, Cadillac also provides a complete engineering service. This service includes help in designing prototypes, as well as assistance in producing finished products.

Stock shapes of Cadco Nylon rod, plate, strip, sheet, tubing and other extruded items are produced and warehoused by Cadillac. Ideal for building prototypes, these shapes can be used as is, or can be machined, blanked, ground, turned and welded or adhesive bonded.

Because material quality is so important, Cadillac depends extensively on Spencer Nylon resins. Stock shapes made of Spencer Nylon are easy to fabricate. They won't rust or corrode and are largely self-lubricating.

For information on how you can take advantage of nylon in your business, contact your Spencer Representative or write direct to Cadillac.

Cadco is a registered trademark of Cadillac Plastic and Chemical Co., 15111 Second Ave., Detroit 3, Michigan.

SPENCER®

SPENCER NYLON

SEE OUR CATALOG IN SWEETS PRODUCT DESIGN FILE

OR WRITE FOR COPY

SPENCER is also a prime supplier of

Poly-Eth Polyethylene

POLY-PRO POLYPROPYLENE

SPENCER CHEMICAL COMPANY, DWIGHT BUILDING, KANSAS CITY 5, MO.

For more information, turn to Reader Service card, circle No. 517

Prices of Materials

*Changes since last semi-annual report in March are bold-faced; *indicates a price decrease*

NONMETALLICS

Prices for large quantities for range of grades, color, sizes; given in $/lb

RUBBER

Material	Dry	Latex
Butadiene-Acrylonitrile	.49-.68	.45-.54
Butadiene-Styrene	.14-.30	.26-.32
Butyl	.23-.28	—
Kel-F	15.0	—
Natural[a]	**.45**	**.48**
Neoprene[b]	.39-.75	.37-.50
Polysulfide[b]	.50-1.25	.80-1.25
Silicone[b]	1.90-4.00	—
Urethane	1.15-1.65	—
Viton	10.0-13.0	—

[a]Average spot price for month of June.
[b]Less than carload quantities for dry rubber.

REINFORCED PLASTICS LAMINATE SHEET

Type	0.025-¼ In.	⅛-2 In.
Paper-Base Phenolic (X, P, PC, XX, XXP, XXX, XXP)	1.03-1.50	.82-1.22
Cotton Fabric-Base Phenolic (C, CE, L, LE)	1.20-2.20	1.36-1.76
Asbestos-Base Phenolic (A, AA)	1.20	.96-2.70
Glass-Base Phenolic (G-3)	3.25	2.60
Glass-Base Melamine (G-5)	2.88	2.30
Glass-Base Silicone (G-7)	6.65	5.90
Nylon-Base Phenolic (N-1)	4.43	3.54

THERMOSETTING PLASTICS

Material	Molding Compounds	Laminating, Casting Resins
Alkyd	.43-.60	—
Epoxy	—	.45-.80
Melamine	.42-.45	.40-.41
Phenolic	.20-.35	.17-.34
Polyester	.31-.39	.33-.53
Silicone	2.75-5.40	1.55-1.74[a]
Urea	.19-.34	—

[a]60% solids content.

All prices are approximate and given solely for general guidance of those responsible for materials selection.

THERMOPLASTICS

Material	Molding Compound: Base	Molding Compound: Per Cu. In. As Molded, ¢[a]	Sheet (.030-.250)	Rod (⅛-¼)	Tube (⅛-¼)
Acetal	**.80***	**4.1**	—	—	—
Acrylic	**.46*-.55***	**1.8-2.3**	.49-2.15	.90-1.15	1-1.15
Chlorinated Polyether	**2.50***	**12.6**	—	—	—
Cellulosic					
Acetate	.36-.58	2.1-2.8	.92-1.16	.75-1	.85-1
Butyrate	.40-.62	2.0-3.0	1-1.28	.95-1.20	1.05-1.20
Nitrate	—	—	1.60-2.73	1.45-1.75	2.25-5.00
Propionate	.62	2.7	—	—	—
Fluorocarbon					
CFE	7-8	53.0-61.0	15-23	18-22	20-22.50
TFE	3.60-5.65	27.2-47.0	11-14	13	13
Nylon	**.98*-2.18**	**4.0-9.0**	—	3	3
Polycarbonate	**1.50***	**9.5**	—	—	—
Polyethylene	.32-.38	1.1-1.3	.85-1	.75-1	.85-1
Polypropylene	**.42*-.58**	**1.3-1.9**	—	—	—
Polystyrene	.22-.43	0.88-1.7	.57-.61	.65-.90	.75-.90
Vinyl	.24-.43	0.10-2.4	.62-.92	.75-1	.85-1

[a]Cost of base molding compound in ¢/lb divided by molded specific volume in cu in./lb.

NONFERROUS METALS

Mill base prices for large quantities; given in $/lb except where indicated

ALUMINUM

Material	Ingot	Sheet[a]	Plate[b]
Primary (99-99.9%)	.28	—	—
13, 43, 214	.30-.33	—	—
1100-F, 3003-F	—	.47-.57	.44
5052-F	—	.53	.47
6061-T6	—	.50	.47

[a]Thickness range 0.048-0.061 in., mill finish.
[b]Thickness range 0.250-3.0 in., mill finish.

BRASS

Form	Cart., 70%	Low, 80%	Red, 85%
Sheet, Strip	.51	.54	.55
Seamless Tubing	.54	.57	.58
Rod (not f.c.)	.50	.53	.54
Wire	.51	.54	.55

NICKEL

Form	"F"	"A"	Monel
Ingot	.76	—	—
Rod	—	1.07	.89
Sheet, C.R.	—	1.38	1.20
Strip, C.R.	—	1.24	1.08
Seamless Tube	—	1.57	1.29

LEAD

Common Grade	.12
Sheets[a]	17.50

[a]Rolls of 140 sq ft or more.

MAGNESIUM

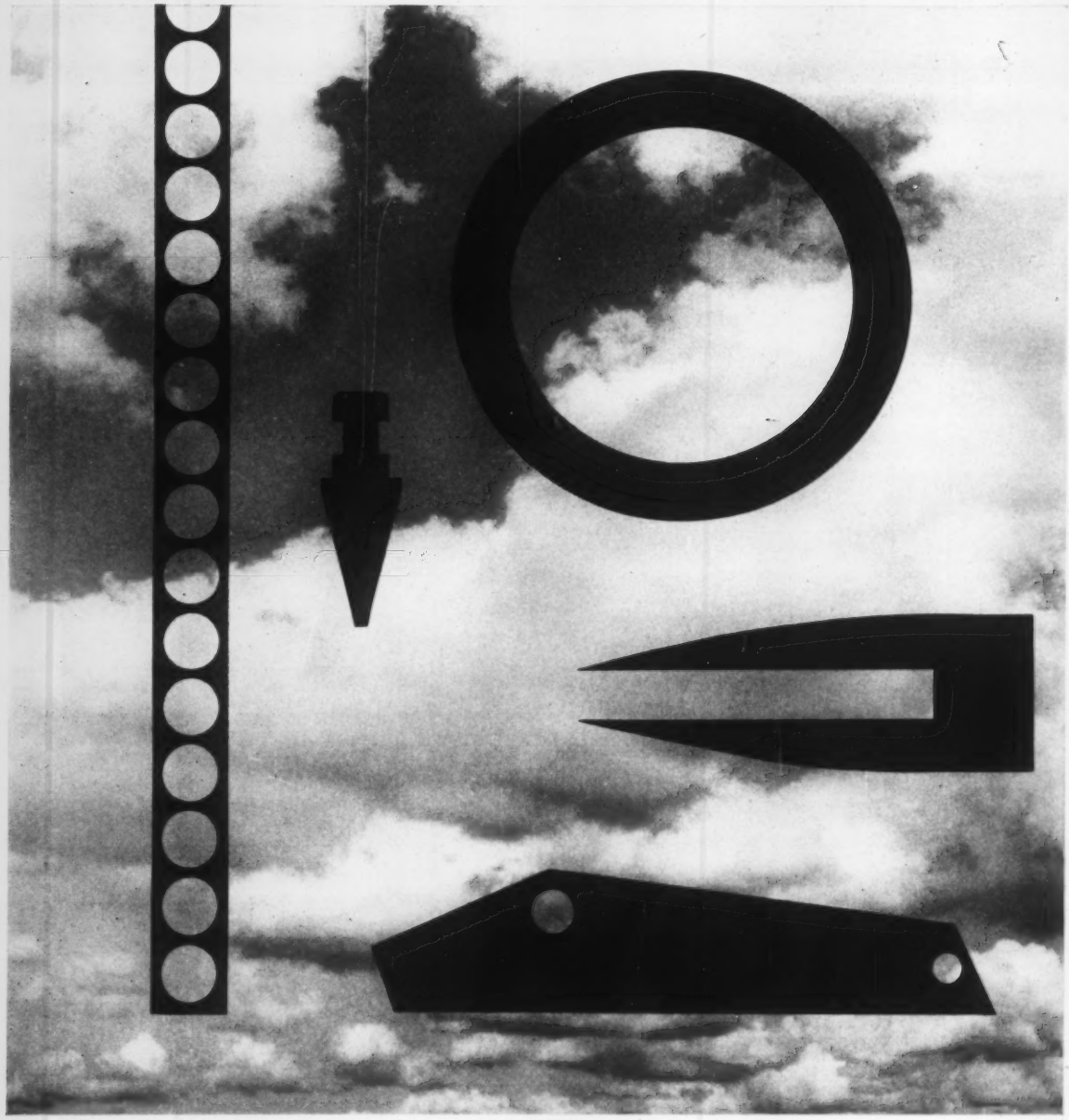
Material	Ingot	Sheet[a]	Plate[b]
Primary (98.8%)	.36-.37	—	—
AZ91B (die casting)	.37	—	—
AZ91C (sand casting)	.41	—	—
AZ31B (std grade)	—	.69-1.03	.68
AZ31B (spc grade)	—	.97-1.71	.93

[a]Thickness range 0.032-0.188 in.
[b]Thickness range 0.250-2.0 in.

COPPER

Ingot (elec)	.35
Sheet, Strip (hot rolled)	.52-.57
Seamless Tubing	.58
Rod, Drawn	.54
Wire	
Round	.38
Square, Rectangular	.42
Magnet	.44

continued on p 217



Meet your changing needs with unchanging quality

Progress has been phenomenal in the plastics industry over the past decade, with hundreds of new uses discovered for plastic laminates. Despite these rapid advancements and new requirements, St. Regis® has retained the original high quality of Panelyte.

Panelyte® offers you its wide range of NEMA and Military Grade Plastics. Complete grade specifications let you select from a full stock of *sheets*, *tubes* and *rods* in a variety of shapes and sizes.

Look to Panelyte as the dependable high-quality plastic laminate. You'll find that there's a Panelyte grade for every purpose–high dielectric strength, low moisture absorption, minimum cold flow under high humidity. Panelyte has excellent machining characteristics, and we are equipped to machine component parts to your exact specifications.

Whenever your engineering specifications call for "laminated, thermo-setting resinous plastic" parts in sheets, tubes or rods – always be sure to specify PANELYTE . . . and be certain of the highest quality plastic laminate. For complete information and the address of your nearest Panelyte distributor, write Dept. MD-9, St. Regis Paper Company, 150 East 42nd Street, New York 17, New York.

St.Regis PANELYTE®

For more information, turn to Reader Service card, circle No. 516

—and here's where to call the PANELYTE distributor nearest you!

ALABAMA
Marine Specialty Company
Mobile, Alabama

ARIZONA
Electrical Specialty Company
Phoenix, Arizona

CALIFORNIA
Cadillac Plastics
Los Angeles, California
Electrical Specialty Company
Los Angeles, California
Cadillac Plastics
San Francisco, California
Electrical Specialty Company
San Francisco, California

COLORADO
Electrical Specialty Company
Denver, Colorado
*Regal Plastic Supply
Englewood, Colorado

CONNECTICUT
Modern Plastic & Glass Company
Bridgeport, Connecticut
*New England Non Metallics Co., Inc.
Milford, Connecticut
Industrial Safety Supply
W. Hartford, Connecticut

DELAWARE
Brandywine Fibre Company
Wilmington, Delaware
Kaufman Glass Company
Wilmington, Delaware

FLORIDA
Commercial Plastics Supply Corp.
Miami, Florida

GEORGIA
AAA Brands Plastic Supply Co.
Atlanta, Georgia
Commercial Plastics & Supply Corp.
Atlanta, Georgia

ILLINOIS
Cadillac Plastics
Chicago, Illinois
Colonial Kolonite
Chicago, Illinois
Insulating Manufacturing Corp.
Chicago, Illinois

INDIANA
*Hyaline Corporation
Indianapolis, Indiana
Cadillac Plastics
Indianapolis, Indiana

KANSAS
D & O Products
Wichita, Kansas

LOUISIANA
Drake-Thompson and Company
New Orleans, Louisiana

MARYLAND
Gilbert Plastics and Supply Company
Baltimore, Maryland

MASSACHUSETTS
Plastic Supply Co. (Hub Stamping)
Boston, Massachusetts
*Insulation Products Company
Chicopee, Massachusetts
H&P Spool & Bobbin Company
Lawrence, Massachusetts
*Laminated Sheet Products
Norwood, Massachusetts

MICHIGAN
Cadillac Plastics
Detroit, Michigan

MINNESOTA
Arrowhead Plastics
Minneapolis, Minnesota
Service Tool & Engineering
Minneapolis, Minnesota
*Minneapolis Manufacturing Co.
Minneapolis, Minnesota
Special Parts, Inc.
Minneapolis, Minnesota

MISSOURI
Regal Plastics Supply Co.
Kansas City, Missouri
Cadillac Plastics
Kansas City, Missouri
Plastic Sales
Kansas City, Missouri
Cadillac Plastics
St. Louis, Missouri

NEW JERSEY
*Insulating Fabricators, Inc.
East Rutherford, New Jersey
*Allied Plastics Supply Corporation
Elizabeth, New Jersey
*Insulating Specialties, Incorporated
Hillside, New Jersey
Kennedy Lumber Company
Trenton, New Jersey
*Rummel Fibre Company
Union, New Jersey
Commercial Plastics & Supply Corp.
Newark, N. J.
Robert McKeown Co., Inc.
Livingston, N. J.
*Delta Plastics
Bellmawr, N. J.
*Philrus Products
Newark, N. J.

NEW MEXICO
*Jay-Grear, Incorporated
Albuquerque, New Mexico

NEW YORK
*Thomas J. Long, Inc.
Carle Place, L. I., N. Y.
*Aircraft Specialties Company, Inc.
Hicksville, New York
*Allied Plastics Supply Corporation
New York City, New York
Commercial Plastics & Supply Corp.
New York City, New York
*Comco Plastics
Ozone Park, New York
The Plastic Center
Rochester, New York
*The Frank Products Corporation
Syosset, L. I., N. Y.

NORTH CAROLINA
*Engineered Plastics, Incorporated
Gibsonville, North Carolina

OHIO
Cadillac Plastics
Cincinnati, Ohio
Cadillac Plastics
Cleveland, Ohio
*Dayton Plastics, Incorporated
Columbus, Ohio
*Dayton Plastics, Incorporated
Dayton, Ohio

OKLAHOMA
Denton's Glass & Plastics
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Tulsa Gasket Mfg.
Tulsa, Oklahoma
Industrial Gasket & Packing Company
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OREGON
Electrical Specialty Company
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PENNSYLVANIA
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Philadelphia, Pennsylvania
*Herschel Engineering & Supply Co.
Philadelphia, Pennsylvania
Commercial Plastics Supply Corp.
Pittsburgh, Pennsylvania
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TEXAS
Cadillac Plastics
Dallas, Texas
Cadillac Plastics
Houston, Texas
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WISCONSIN
Rahrs Engineering
Manitowoc, Wisconsin
Cadillac Plastics
Milwaukee, Wisconsin
*Asbesto Fab
Milwaukee, Wisconsin
*General Plastics
Milwaukee, Wisconsin

***Distributor-Fabricators who can give special attention to your fabrication needs.**

TITANIUM

Sponge (99.3+%)	1.50-1.60
Bars, Rod	3.80*-6.25
Plate	5.25-9.00*
Sheet, Strip	6.75*-15.50*
Wire	5.55-9.50

ZINC

Prime Western	.13
Die Casting Alloys[a]	.17
Sheet	.28
Ribbon	.23
Plates	.22

[a]Alloys 2, 3, 5.

NONFERROUS POWDERS

Aluminum [a,b]	.39
Brass[a]	.35-.52
Copper (elec or red.)[a]	.44
Molybdenum (98%)	3.15-4.10
Nickel	1.15
Tantalum	30
Tungsten (C-red. 98.8%; H_2-red. 99+%)	3-4[a]
Zirconium	
Flash Grade	4
Electronics Grade	15

[a]Price for -100 mesh. [b]Freight allowed. *Delivered price.

OTHER NONFERROUS METALS

Cadmium (bars)	1.50
Columbium	55-85
Gold	$35/troy oz
Indium (99.97+%)	$2.25/troy oz
Manganese (99.9%)	.34-.38[a]
Palladium	$24-26/troy oz
Platinum	$82-85/troy oz
Silver	90-91¢/troy oz
Tantalum (sheet, rod)	55-60
Tin (Straits)[b]	1.04
Vanadium (90%)	3.65
Zirconium (sheet, strip, bar)	20-30

[a]Delivered price. [b]Spot.

IRONS AND STEELS

Mill base prices for large quantities

SEMIFINISHED STEEL ($/net ton)

Ingots, Alloy	82
Billets, Blooms, Slabs	
Carbon, Re-Rolling	80
Carbon, Forging	99.50
Alloy, Forging	119
Seamless Tube Rounds	122.50
Wire Rods	$6.40/cwt

(continued on p 218)

machine all these small parts from

Bearings
Blanks
Bushings
Cams
Clutch Plates
Collets
Cylinders
Dies
Discs
Gauges
Gears
Jigs
Liners
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Pistons
Plug Laps
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Seals
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Valve Guides
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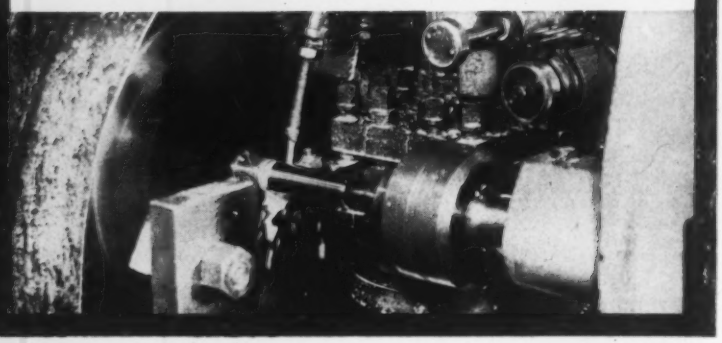
Washers

6' SHENANGO IRON BARS



Now, many parts formerly cast to shape can be machined at lower cost from Shenango solid bars and centrifugally cast tubular bars.

Bars and tubes are available centerless ground for automatic screw machines or as cast for turret or engine lathe work. Expensive patterns are eliminated. Uniformity is guaranteed. Inventory is reduced. Production output is increased.

Write on your letterhead for a machining sample of Meehanite Metal, Ni-Resist or Ductile Iron. Centrifugally Cast Products Division, The Shenango Furnace Company, Dover, Ohio.

SHENANGO CENTRIFUGAL CASTINGS

COPPER, TIN, LEAD, ZINC BRONZES • MANGANESE AND ALUMINUM BRONZES
MONEL METAL • NI-RESIST • MEEHANITE® METAL • ALLOY IRONS • DUCTILE IRON

For more information, turn to Reader Service card, circle No. 458

PRICES & SUPPLY

FINISHED STEEL (¢/lb)

Form	Carbon	High Str Low Alloy	Alloy
Plate	5.30	7.95	7.50
Sheet, HR	5.10	7.52	—
Sheet, CR	6.27	9.27	—
Strip, HR	5.10	7.57	8.40
Strip, CR	7.42	10.80	—
Bar, HR	5.67	8.30	6.72
Bar, CF	7.65	—	9.02

STAINLESS STEELS ($/lb)

Material	Forging Billets	H. R. Bars	Plate	Sheet, Strip
Austenitic				
301, 302, 302B, 303, 304, 305	.39-.50	.46-.50	.41-.46	.51-.57
321*	.49	.58	.55	.66
347*	.58	.67	.65	.79
Martensitic				
410*	.29	.35	.30	.40
416	.30	.36	.31	.48
403	.29	.35	.30	.40
420, 440	.36	.43	.40	.62
Ferritic				
405, 430, 430F*	.31	.36-.37	.31-.33	.41*-.52
442	.33	.40	.37	.56
431	.39	.46	.41	.56
446	.41	.48	.43	.70
High Mn				
202*	.38	.45	.40	.49
Extra Low C				
304L	.50	.57	.54	.63
316L	.72	.84	.80	.89
Precip Hard.				
17-7PH	.69	.76	.85	.90
PH 15-7 Mo	.89	.97	1.11	1.16

*Ingot price approx 60% of billet price.

FERROUS POWDERS ($/lb)*

Sponge Iron	.11
Electrolytic Iron	
Annealed (99.5%)	.37
Unannealed (99+%)	.33
Stainless Steel	
304	.89
316	1.07*

*Price for −100 mesh.

IRON ($/gross ton)

Pig	66-67

(continued on p 220)

Escon® POLYPROPYLENE

for colorful, new non-slip rope...super-strong and it floats!

Another interesting use of versatile Escon: as rope, Escon filaments are easier on the hands than manila fibers. They don't have that greasy, slippery feeling noticeable in some other synthetic rope materials. Water absorption—a problem that plagues many cordage materials—is virtually eliminated with Escon filaments. Escon exhibits other desirable properties, too. Excellent wet strength—plus chemical and abrasion resistance—and full flexibility can be maintained at temperatures as low as minus 70°F. Brilliant color coding is also possible for easy identification. And Escon has shown no evidence of attack by fungus, rot and marine organisms. Escon as a filament can help produce better cordage as well as countless other products. Investigate Escon today!

For technical assistance or to order Escon, phone or write the Enjay office nearest you. (Home office) 15 West 51st Street, New York 19, N. Y. Other offices: Akron • Boston • Charlotte • Chicago • Detroit • Houston • Los Angeles • New Orleans • Tulsa

EXCITING NEW PRODUCTS THROUGH PETRO-CHEMISTRY

ENJAY CHEMICAL COMPANY

A DIVISION OF HUMBLE OIL & REFINING COMPANY

ENJAY PLASTICS

For more information, turn to Reader Service card, circle No. 366

Put **PERMALI** into your design plans!

PERMALI

the laminate of many uses!

. . . as a non-metallic structural material — tensile strengths to 30,000 p.s.i.—parts to 13 feet long and 5 inches thick—tailored mechanical properties to fit your needs—machines easily to engineering tolerances.

. . . as a dielectric—high dielectric strength—low power factor—used by every major heavy electrical equipment manufacturer.

. . . as a non-metallic fastener—available off the shelf as studs, continuously threaded rods or bolts with matching square or hexagon nuts.

. . . as a silent gear—special grade gives uniform tooth strength. Diameters to 48", face widths to 4".

. . . as thermal insulation at very low temperatures—Permali retains most of its mechanical strength at the temperature of liquid gases.

. . . as a neutron shield—a special grade provides structural strength while shielding against fast neutrons.

And Permali, Inc. can design, machine or build your parts or structures regardless of size.

Technical literature on any or all the above applications available on request to

PERMALI, Inc.

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Mt. Pleasant, Pa.

Telephone: KImball 7-2353

TWX: MT PL PA 161

For more information, turn to Reader Service card, circle No. 532

PRICES & SUPPLY

CLAD STEELS (¢/lb)[a]

Cladding Metal	10%	15%	20%
Stainless			
304	29	32	34
304L	34	37	40
316L	47	51	56
321	35	38	41
347	41	45	49
430	23	26	28
Inconel	61	73	84
Nickel	55	66	78
Monel	55	66	77

[a]Prices given for three cladding thicknesses.

TIN PLATE ($/base box)

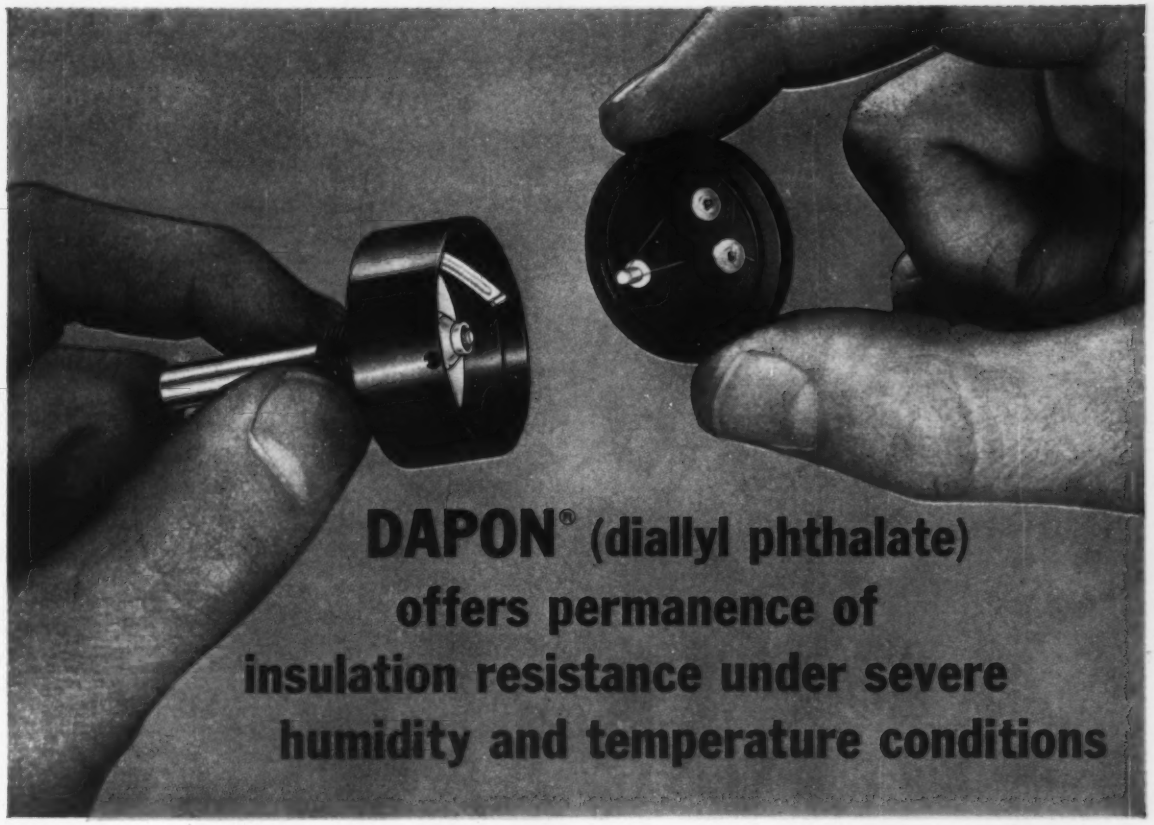
Hot Dip (1.25-1.50 lb)	10.40-10.65
Electrolytic (0.25-0.75 lb)	9.10- 9.75
Black Plate	8.20

FINISHES AND COATINGS

ORGANIC COATINGS

Material	Avg Thk per Coat, mil	Mils Required[a]	Cost, ¢/sq ft/dry mil[b]
VARNISHES, ENAMELS			
Short Oil Phenolic			
Varnish	1.0	1.0	1.5
Enamel	1.2	1.0	1.75
100% Phenolic	1.0	1.5	1.75
Straight Oil-Modified			
Alkyd	1.5	1.5	1.5
Alkyd-Amine (90-10)	1.5	1.5	1.75
Alkyd-Phenolic (50-50)	1.5	1.5	1.75
Alkyd-Vinyl (50-50)	1.0	2.0	2.0
Alkyd-Styrene (70-30)	1.2	1.5	1.75
Epoxy	1.8	1.8	2.0
Silicone	.5-1.0	.5-1.0	6.0
Furane	2.0	2.0	1.0
Neoprene	5.0	5.0	1.5
DISPERSION COATINGS			
Phenolic	1.0	1.5	1.75
Vinyl	1.0	2.0	2.5
Fluorocarbon	1.0	1.0	15.0
LACQUERS			
Nitrocellulose	1.0	2.0	2.5
Vinyl	1.0	2.0	2.5
Acrylic	1.0	2.0	2.75
Butyrate	1.0	2.0	2.75

[a]Thickness over phosphate coating required for exterior durability on steel. For purely decorative coating, 1 mil will usually suffice.
[b]Materials cost only. Realistic price comparison can be made only on basis of dry applied coating, not on basis of cost per gallon.



DAPON® (diallyl phthalate) offers permanence of insulation resistance under severe humidity and temperature conditions

This plastic is ideal for applications where changes in humidity can affect electrical values. DAPON can prevent costly "in service" failures in electrical and electronic components.

A new molded plastic potentiometer produced by New England Instrument Company features exceptional resistance to humidity, high reliability and low noise. A raised conductive plastic ring is used in place of resistance wire in these miniature units. The new potentiometers are ideal for servo and instrumentation applications where long life and extreme accuracy are important factors.

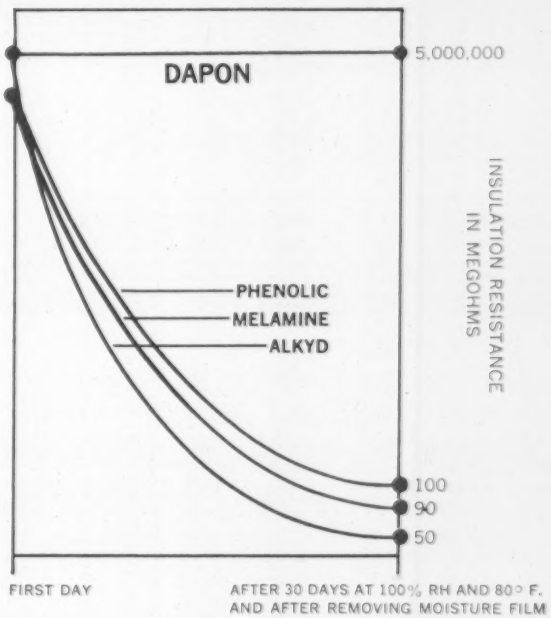
The solid resistance element, insulating base and silver terminal leads are molded in one operation with DAPON (diallyl phthalate) Resin. Result: a single, almost indestructible precision unit.

New England Instrument chose DAPON because of its superior electrical and physical properties, and its low moisture absorption. DAPON also molds easily around metal inserts without cracking, and withstands extremes of temperature, vibration and shock.

Specify DAPON (diallyl phthalate) Resin when you need:

- Low dielectric loss
- High dielectric strength
- Superior dimensional stability
- Excellent arc resistance
- High volume and surface resistance after high humidity-high temperature conditioning

Write for FMC's data sheet containing technical information about DAPON, suggested uses for this resin, and the names of DAPON compounders.



FOOD MACHINERY AND CHEMICAL CORPORATION
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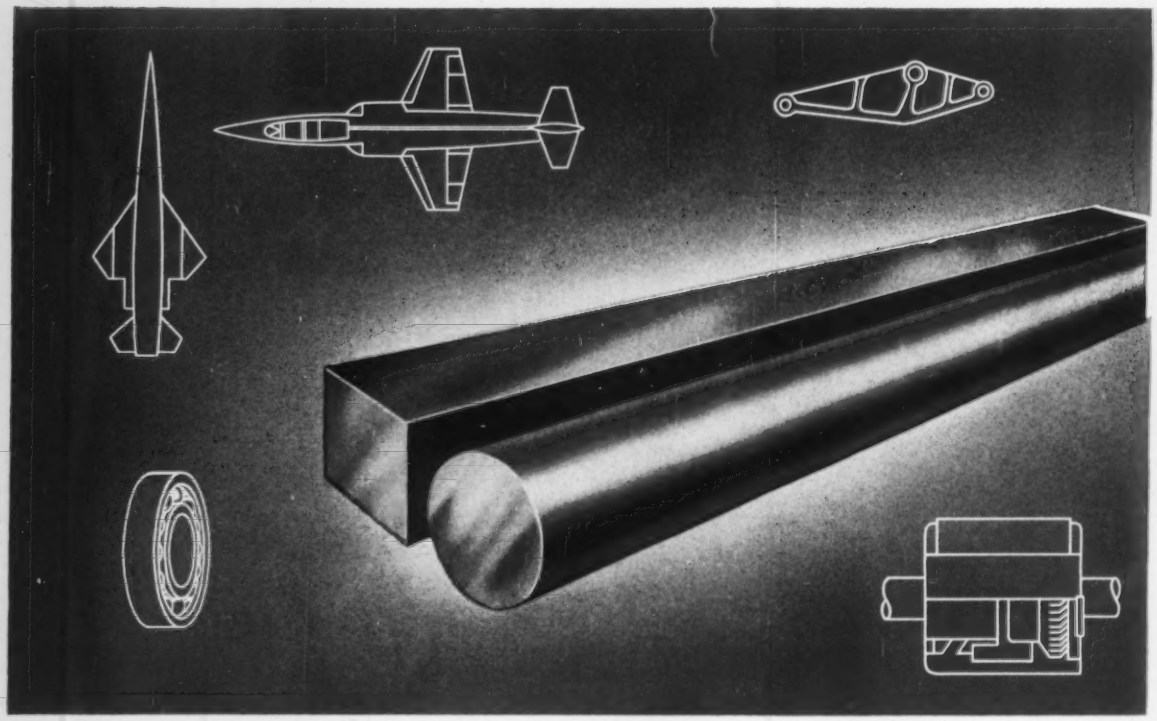
For more information, turn to Reader Service card, circle No. 370



DEPENDABLE VAC-ARC® Steels

. . . for applications requiring high ductility and tensile strength up to 285,000 psi.

Compare these data . . .

TRANSVERSE TENSILE PROPERTIES 8" square billet of VAC-ARC DYNAFLEX		
Property	*Mid-Radius*	*Center Area*
Tensile Strength (psi)	287,000	285,000
Yield Strength .2% (psi)	252,500	250,000
Elongation %	8	8
Reduction of Area %	25	24

Literature available on all Vac-Arc grades upon request . . . Send today!

Where design demands uniform high strength, toughness and ductility at both low and elevated temperatures, Vac-Arc Steels more than meet the requirements. These steels—produced by Latrobe's consumable electrode vacuum melting process—possess superior cleanliness, lower gas content, improved ingot structure and desirable longitudinal and transverse mechanical properties.

The following grades of Latrobe's Vac-Arc steels are available in a range of sizes and shapes: Pandex (Type A-286) for high temperature applications; MV-1 (Type M-50) and Regent (Type 52100) for critical bearing design; Dynaflex (Type H-11) for aircraft and missile components; AGT (SAE 9310) for carburized aircraft gears.

Many grades of Vac-Arc steels are being produced to meet particular application requirements. Send us your specifications or call your nearest Latrobe representative for *experienced* technical assistance.

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For more information, turn to Reader Service card, circle No. 404

(cont'd from p 18)

What's new IN MATERIALS

Chlorinated Polyether Coating Sprayed On Complex Shapes

■ Development of a water suspension type of chlorinated polyether that can be spray applied is expected to open up new uses for chlorinated polyether coatings on chemical, petrochemical, pharmaceutical, and pulp and paper equipment.

Previously, chlorinated polyether coatings could only be applied by the fluidized bed process (see M/DE, Feb '60, p 91). The new water suspension type of coating is easier and cheaper to apply. Chlorinated polyether has excellent resistance to corrosion at temperatures to 250 to 275 F, and is also noted for its high resistance to abrasion and impact.

To date, the coating has been given a year's field test on such items as tanks, pumps, flow meters, centrifuge parts, drum dryers, fume ducts and filters.

Developed by Pfaudler Co., West Ave. & Clark St., Rochester 3, N. Y., the new coating is especially distinguished by its ease of application: coatings from 20 to 40 mils thick can be applied in as few as two operations. In contrast to the fluidized bed process, no preheating is required. Also, complex shapes now can be easily covered, and surfaces not requiring the coating can be easily excluded.

The new coating is applied in much the same way as coatings in organic suspension. After cleaning the surface by sandblasting or other methods, the coating is applied with standard spray equipment. The water is then driven off and the coating fused to the metal by heating at 400 to 500 F. Elaborate safety measures are not needed to guard against toxicity and flammability because the coating is in a water suspension.

In addition to Pfaudler, the coating is available through three principal licensees—American Durafilm

Water *suspension of chlorinated polyether is sprayed on cold metal.*

Somers THIN STRIP

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Only metallic computer tape assures the resistance to stretching or distortion under heat and the complete non-absorption of water necessary to preserve important data like the U. S. census indefinitely under varying environmental conditions.

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2) processing economy with coils of .001" metal up to 14,000 feet long without joining.

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Reader Service card, circle No. 417

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For more information, turn to Reader Service card, circle No. 401

Co. in Boston, Mercer Rubber Co. in New York City, and Electrochemical Engineering and Mfg. Co. in Emmaus, Pa. It is expected that more firms will be licensed even though Pfaudler expects to perform much of the work. KEY NO. 608

Composite Materials Designed for Reactors

Better and longer lasting nuclear equipment is promised with the development of a new group of composite materials called Sinterwrought. The materials are essentially dispersions of one element or compound in a metal or alloy.

The composite materials, first announced last year (see M/DE, Jan '59, p 4), are now commercially available from Sintercast Div., Chromalloy Corp., 132 Woodworth Ave., Yonkers 2, N. Y.

Composites made by powder metallurgy technique

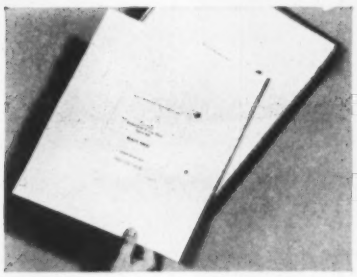
The materials are made by what is described as an "advanced powder metallurgy technique" in which carefully weighed constituents are thoroughly mixed in special mills, then formed into green compacts using hydrostatic presses. The compacts are then sintered at a temperature below the melting point of any constituent. During sintering, a diffusion process bonds the metal particles together, forming a porous composite. The compacts are then hot worked to achieve full density.

Two nuclear-grade products

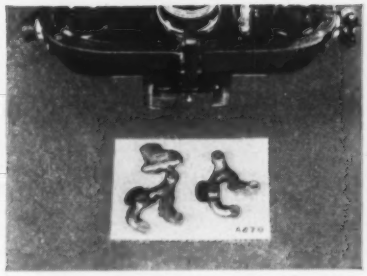
Two nuclear-grade products resulting from the process are Bo-Stan, a uniform dispersion of boron in stainless steel, and Binal, a uniform dispersion of boron carbide in aluminum.

Bo-Stan is said to be as dense, ductile and strong as a cast alloy of similar composition. But its chief advantage is that boron does not segregate out of the material.

According to J. L. Ellis, general manager of Sintercast, "The Sinterwrought process permits more precise control of composition and greatly reduces the problem of deboronization. With conventional alloying procedures, boron cannot be dispersed uniformly in stainless steel



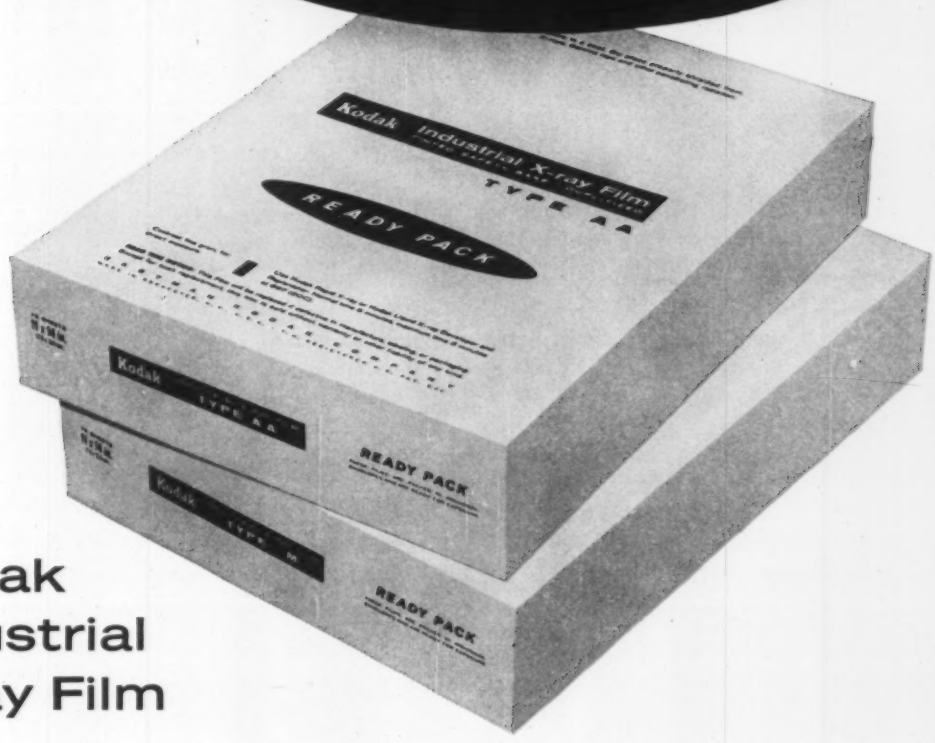
1) No darkroom loading. Ready for exposure as it comes from the box.



2) Just place in position and expose —the film is protected from dust, dirt, light and moisture.

3) In the darkroom, pull the rip strip, remove film, and process.

...NEW!... READY PACK ....



Kodak Industrial X-ray Film

Sealed tight until processed—keeps clean

Very convenient to handle—saves time

Readily available in Type AA and Type M

Here's new convenience when you are inspecting aluminum or magnesium alloys, thin steels, plastic or anything where lead screens are not required.

Kodak Industrial X-ray Film, Type AA and Type M-Ready Pack comes to you with each sheet sealed in a light-tight envelope ready for exposure. A convenient rip strip makes it easy to open in the darkroom.

These films come 75 to a box in sizes 8 x 10, 10 x 12, 11 x 14, 14 x 17. Order them from your Kodak X-ray dealer.

EASTMAN KODAK COMPANY
X-ray Division • Rochester 4, N. Y.

Kodak
TRADE MARK

For more information, turn to Reader Service card, circle No. 364

From these rings in aircraft hydraulic systems to high-temperature electrical insulation, "Teflon" from R/M answers the needs of modern design men . . . and R/M facilities meet modern production schedules.

"TEFLON" comes of age at R/M

No longer is "Teflon"* the baby of the design field. In the hands of skilled processors like R/M, "Teflon" has solidly proved its unique properties in this field.

R/M has always offered "Teflon" in the widest range of forms and sizes—rods, sheets, tubes, tape, a variety of machined parts; and was among the first to offer etched "Teflon" for bonding. From R/M you get *complete "Teflon" service.*

When you bring your "Teflon" problem to R/M, it's in good hands, because R/M has helped solve other problems for an impressive list of exacting designers.

Call the nearest R/M district office listed below or write Plastic Products Division, Raybestos-Manhattan, Inc., Manheim, Pa.

*Du Pont TM for its TFE-fluorocarbon resin

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SPECIALISTS IN ASBESTOS, RUBBER, ENGINEERED PLASTICS, SINTERED METAL

For more information, turn to Reader Service card, circle No. 443

What's new IN MATERIALS

Coiled strip *of boron-containing aluminum is designed for use in nuclear reactors. Coiling demonstrates ductility of the sintered and wrought composition.*

because it segregates, resulting in an alloy that has more boron in some areas than in other areas."

Ellis says that powder metallurgy techniques also permit easier regulation of particle size and closer control over microstructure than are possible with conventional melting and casting techniques.

Presently, up to 2% boron can be incorporated into Bo-Stan, but composites containing larger amounts of boron are soon expected on the market.

The new product is recommended for use as a flux attenuator in pressurized water reactors.

Binal, because of its affinity for neutrons, is expected to be used as a burnable poison to reduce reactivity when starting a nuclear cycle. It is also expected to be used for neutron shielding. The producer says the isotope boron-10 can be substituted for natural boron in Binal for even greater neutron absorption.

The composite is furnished as foil ¼ in. thick, 5 ft wide and 10 to 12 ft long.

Other composite materials

The powder metallurgy technique is also being used to produce such rare earth composites as dysprosium, gadolinium, samarium, europium and holmium dispersed in either aluminum or stainless steel.

According to the producer, all Sinterwrought composites can be supplied in the form of tubing, strip, foil, plates and custom shapes. A typical custom shape is a bushing

application and a free
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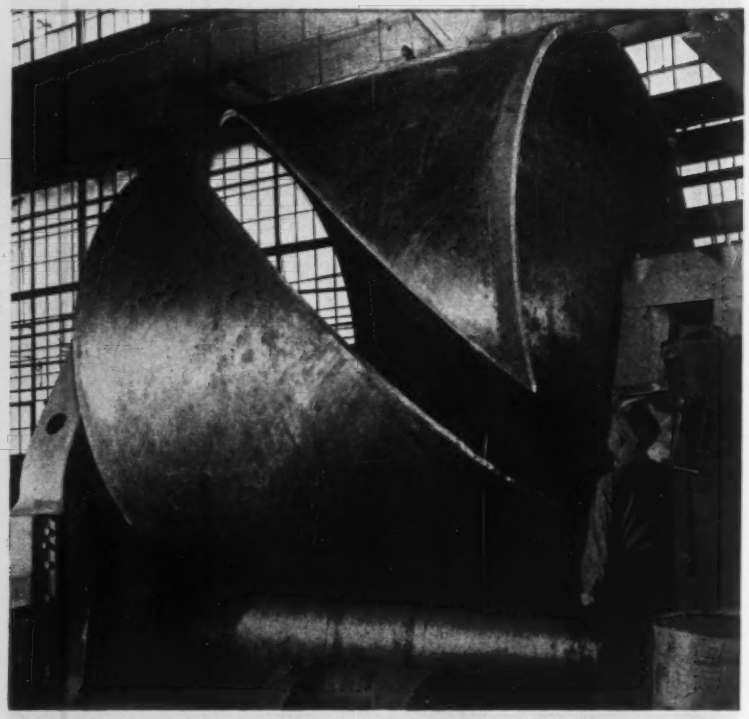
BIG BRONZE PLATE!

**Varying dimensions—
up to 10,000 lbs. in weight**



Here's an idea of what you can get in

AMPCO® METAL

A single Ampco Metal plate can be big enough (½" x 192" x 360") to form a tank 16' high x 11'-6" diameter! Big enough (1" x 180" x 240") to form a tank 15' long x 5'-3" diameter!

An Ampco Metal Tube Sheet 2" thick can be rolled 10'-6" in diameter. One 3" thick can be 9'-0" in diameter.

What are *your* requirements for corrosion, abrasion, or mechanical service? Talk it over with your Ampco field engineer. Write for bulletin.

G-23C

AMPCO METAL

AMPCO METAL, INC.
Dept. 101. Milwaukee 46, Wis.
West Coast plant: Huntington Park California
Southwest plant: Garland (Dallas County), Texas

For more information, turn to Reader Service card, circle No. 331

made from gadolinium oxide dispersed in aluminum, measuring ½ in. in dia by ⅝ in. long, with a wall thickness of 0.014 in.

KEY NO. 609

Tougher High Impact Polystyrenes Available

Development of two new high impact polystyrene resins with improved toughness characteristics has been announced by Dow Chemical Co., Midland, Mich.

Added to the company's Styron 475 high impact series, the new resins are trademarked Styron 475B and Styron 475C. Dow says the resins have good impact properties at both room and low temperatures.

The materials are recommended for refrigerator door liners, hot drink cups, containers, and small appliance parts. They sell for 28½¢ per lb for natural grades and 30¢ per lb for colored grades in truckload quantities.

475B is an extrusion resin recommended for thermoforming operations where the plastic is first extruded into sheet and then formed by heat and pressure.

475C is a molding resin designed for use in most molding applications, especially thin section parts or those where long flow areas are encountered.

KEY NO. 611

Jacketed Insulation Effective to 1200 F

A high temperature insulation with an embossed, ripple-textured aluminum jacket can be applied easily and quickly on industrial piping.

The product, developed by Owens-Corning Fiberglas Corp., Toledo 1, Ohio and known as Kaylo-Klad pipe insulation, is said to be effective at temperatures up to 1200 F. It is designed for piping in the power, chemical and refining industries as well as other industrial and processing uses.

The insulation is made of lime and silica. The aluminum jacket, which has a "no-glare" appearance, protects the new pipe insulation

HAYNES ALLOYS

RESEARCH REPORTS

Developing new metals and improving current ones to combat the devastating effects of high heat, corrosion, erosion, and abrasion, are the primary objectives of the advanced Research and Development Laboratories at Haynes Stellite Company. HAYNES Tantalum, described below, is one of their more recent achievements. Others will be described in future Research Reports.

Design engineers, metallurgists, and physicists may see in these new metals and alloys opportunities for a breakthrough in applications where limited properties of other metals have presented obstacles. Our research scientists, engineers, and technicians will gladly help you discover whether they can help improve your products.

HAYNES Tantalum

Close to 100% pure, chemically. It is produced by the consumable-electrode process. Practically inert to a wide variety of corrosive media, with these added advantages: *Wide* sheets with improved welding characteristics, making it easier to use in chemical and pharmaceutical equipment where corrosion and product contamination must be minimum. Pictured is tantalum reactor liner being welded inside tank of inert gas.

LARGEST Tantalum Lined Reactor

An outstanding example of what can be accomplished with the greater sheet width and improved welding characteristics of HAYNES Tantalum is shown above. The vessel—the largest tantalum-lined reactor ever constructed—is a 30-gallon unit designed to operate at 630 deg. F. and 500 psi. Every part that will be exposed to corrosives, including the agitator, is made, or sheathed with, HAYNES Tantalum. For full details on this new material, write for descriptive booklet.

HAYNES ALLOYS

HAYNES STELLITE COMPANY

Division of Union Carbide Corporation

Kokomo, Indiana

UNION CARBIDE

Address inquiries to Haynes Stellite Company, 270 Park Ave., New York 17, N. Y.

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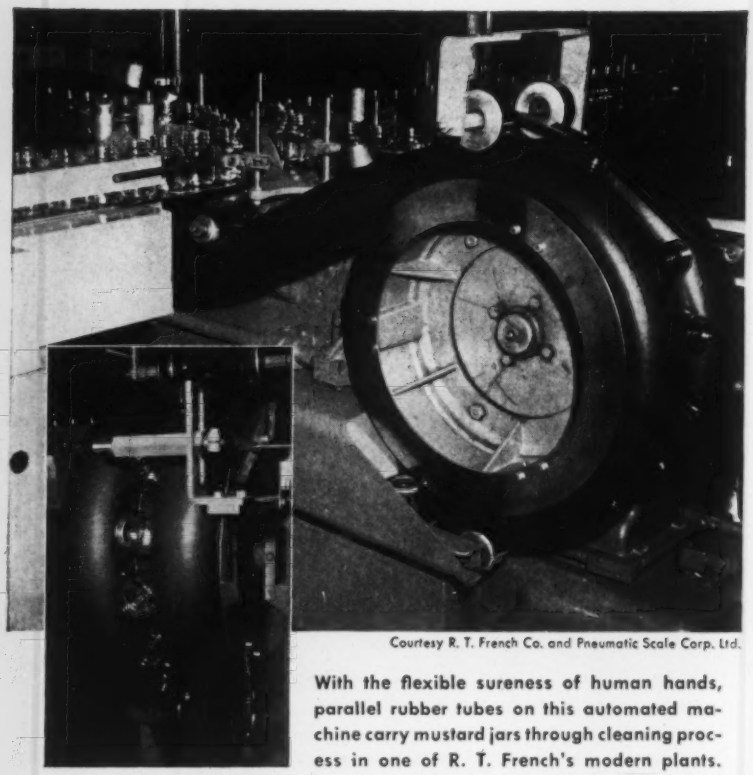

Courtesy R. T. French Co. and Pneumatic Scale Corp. Ltd.

With the flexible sureness of human hands, parallel rubber tubes on this automated machine carry mustard jars through cleaning process in one of R. T. French's modern plants.

Pneumatic Rubber Tubes Solve Delicate Handling Problem

Guided by two large pulleys a pair of lightly inflated rubber tubes pick up glass jars from a flat conveyor at the rate of 240 per minute. With a cushion grip that conforms to these irregularly shaped containers the rubber tubes invert the jars and, without ever dropping one, carry them over jets of 60-psi air for scrupulous cleaning.

The success of this unique device depends on ability of the tubes to hold each jar with uniform, safe tension. To do this, the rubber tubes must retain their given size, shape and resilience while constantly stretching and flexing. Superior impermeability is also essential to prevent any dissipation of air even after long periods of use. Furthermore, the tubes must not kink or collapse when taking relatively sharp turns, especially with the thin tube wall and large cross section.

To save the customer extra equipment costs, the "stretch" of the compound was prefigured so that the manufacturing size would inflate to the proper working size without adjustments.

These exacting specifications require a precise blend of synthetics, processed and cured with the expert techniques of rubber specialists to assure a practical, functional rubber compound of exceptionally long working life.

This is another example of the complete engineering, laboratory and manufacturing service given to rubber parts produced by Continental. Next time your product calls for rubber parts, consult Continental—use this specialized help to save both tooling and material costs and still get rubber components that are practical, functional and dependable.

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What's new IN MATERIALS

High temperature insulation *is easy to apply on industrial piping.*

against damage and weather.

The longitudinal seam of the jacket snaps together with interlocking lips. End joints are sealed with a band containing an integral sealing compound. The insulation can be removed for inspection or pipe repairs by removing the joint strap and sealer bands and separating the longitudinal seam.

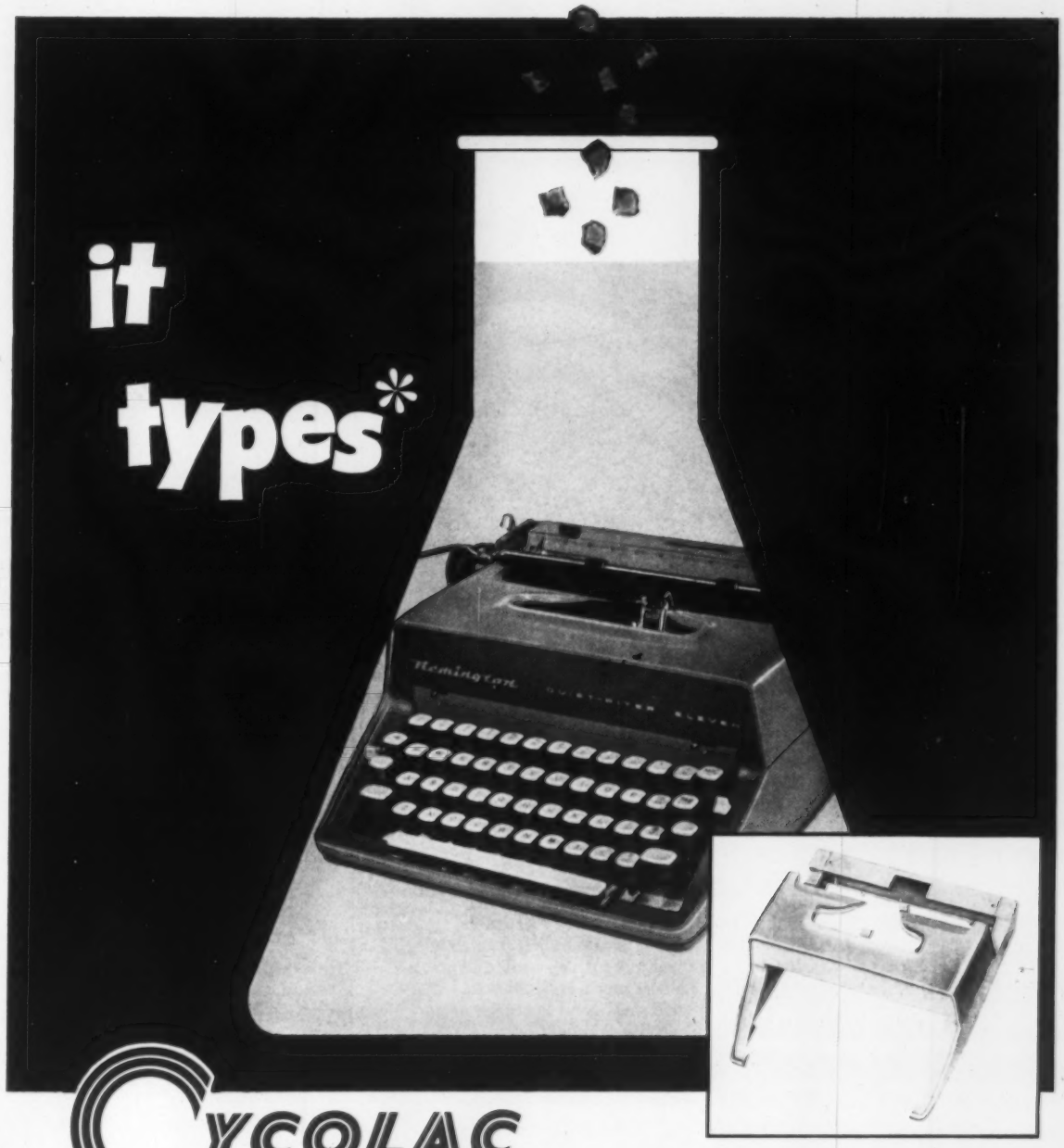
KEY NO. 612

Pyroceram Cement Seals Glass, Metals

A new Pyroceram glass-ceramic cement has been developed by Corning Glass Works, Corning, N. Y. for sealing glasses and other materials that have thermal expansions ranging between 44 and 51 $\times 10^{-7}$ per °F. It is called Pyroceram brand cement No. 89.

Pyroceram is the tradename for a group of materials that are essentially crystallized glasses (see M/DE, July '57, p 142). Other grades of Pyroceram cements are also available from Corning (see M/DE, July '58, p 126).

The new cement fires at approximately 840 F, and the resulting seal is serviceable at temperatures up to about 800 F. According to Corning, the cement was developed to meet a demand for a sealing substance that would match very closely the thermal expansion of glasses used in industrial and military cathode ray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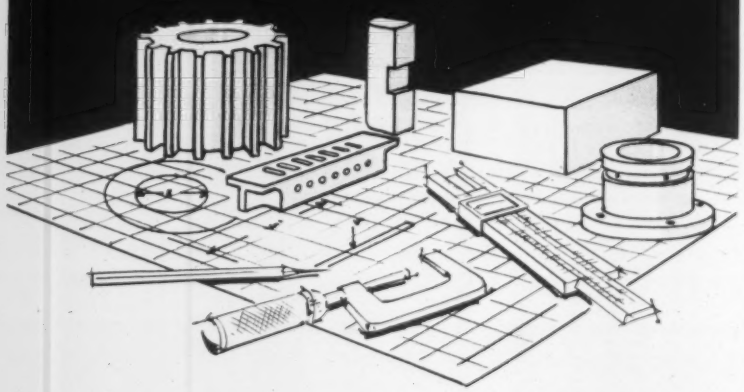
whatever your product specifications...

ALL MATERIALS ARE NOT CREATED EQUAL



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Laminated and fabricated INSUROK parts assure top performance because of their unique combination of desirable plastic properties. INSUROK is strong and durable, highly dielectric, chemically-inactive, non-corrosive, heat and moisture-resistant. Weight . . . half as much as aluminum. It allows new design flexibility and has good machining qualities. Usually, no additional protective or decorative finish is needed. And, new grades are constantly being developed for new, challenging design applications.

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For more information, turn to Reader Service card, circle No. 450

What's new IN MATERIALS

PROPERTIES OF PYROCERAM CEMENT NO. 89

Mod of Rupture, psi	
77 F	6000
750 F	4800
Dielectric Constant (100 kc)	
77 F	19.8
450 F	21.8
700 F	25.6
Loss Tangent (100 kc)	
77 F	0.001
450 F	0.014
700 F	0.250

bulbs. It also seals metals, ceramics and combinations of these materials.

The cement is a finely powdered glass that is applied in a low viscosity vehicle to the sealing area by dipping or pressure flow. Upon firing, it partially crystallizes, resulting in a vacuum-tight, devitrified seal.

It is supplied in 1 and 5-lb kits that include powder and vehicle, or in any quantity without the vehicle. Price of a 1-lb kit or 1 lb of powder is $12.50. KEY NO. 613

Polyethylene Films for Packaging, Glazing

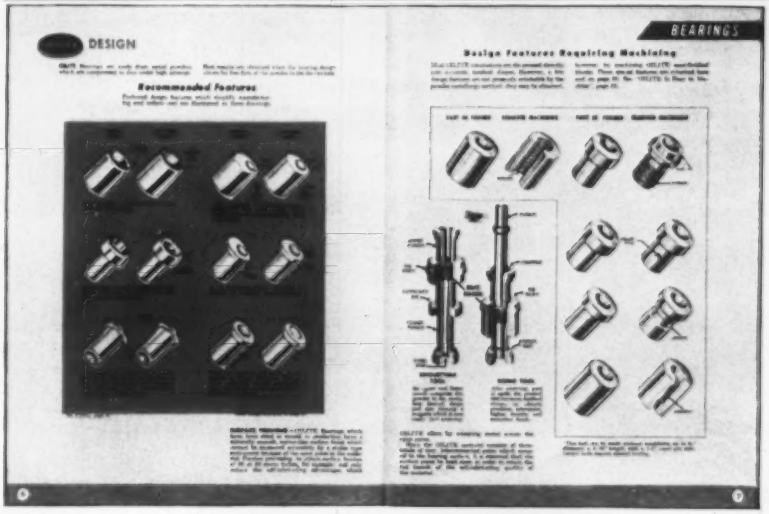
Two new films have been added to a line of polyethylene films available from the Film Dept. of E. I. du Pont de Nemours & Co., Inc., Wilmington 98, Del. One film is designed for packaging applications and the other for glazing.

1. Packaging film

Du Pont's polyethylene packaging film is said to combine high strength with high clarity. Bag drop tests show that the film withstands 25% more drops than presently available high impact films of the same thickness, and 150% more drops than high clarity films.

Clarity of the film has been indicated by gloss meter readings and other tests. According to Du Pont, the gloss meter, normally adjusted at a 45-deg light angle, recorded such a high reading that it was reset at 20 deg, where the reading was in the range of 70 photovolts, a gloss described by Du Pont technicians as greater than that of any presently available bag film. Haze

POWDER METALLURGY ENGINEERING MANUAL



HOW TO determine the correct applications for self-lubricating bearings and powder metal parts. **Bearing** section includes: design features, computation of loads and speeds, calculating nominal dimensions, examples of designing for both new and existing applications —plus stock list of 1050 standard Oilite bearings. **Powder metal parts** section includes: typical properties, materials selection guide, design features, magnetic properties, information request form.

56 PAGES PACKED WITH TECHNICAL INFORMATION

Amplex (Oilite) is the largest and most experienced producer of powder metal parts, bearings, filters. Amplex engineering and development staff, the largest in the industry, is available to you at any time for consultation on powder metal applications.

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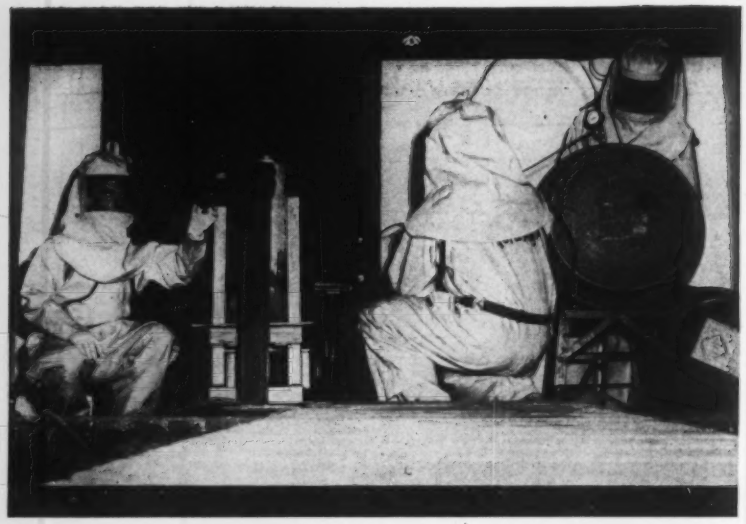
The Advance guarantee is backed by unique production controls and highly developed state-of-foundry-arts which practically eliminate rejections to keep costs down and quality up, up, up.

Castings up to 80,000 pounds . . . delivered on schedule.

THE ADVANCE FOUNDRY COMPANY . . . makers of Strenes metal
107 SEMINARY AVENUE., DAYTON, OHIO

For more information, turn to Reader Service card, circle No. 320



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readings show the film has a haze concentration of less than 5%.

KEY NO. 614

2. Glazing film

SR-300 is the name given to Du Pont's new polyethylene film designed for glazing greenhouses, cold frames and farm buildings. The film is said to have an outdoor life three to four times that of standard, clear polyethylene film. The film is supplied in a variety of widths.

KEY NO. 615

Film Stops Tarnish on Copper and Brass

Entek CU-56 is the name of a new rinse water additive that inhibits corrosion of copper and brass. It is available from Enthone, Inc., 442 Elm St., New Haven 8, Conn. The additive sells for $6 per gal in 55 gal drums.

The product produces an invisible film that is said to prevent tarnishing, staining, spotting-out, green salt formation, pit corrosion and finger marking of copper and its alloys. It is designed to preserve freshly plated or cleaned metal surfaces during storage.

The additive is a neutral liquid that is used at a concentration of 1 gal to every 99 gal of water. One gallon of the made-up Entek CU-56 rinse will treat approximately 500 sq ft of metal surface. According to the producer, a brief immersion of 5 to 30 sec is enough to provide protection against 200 hr of tropical humidity conditions. KEY NO. 616

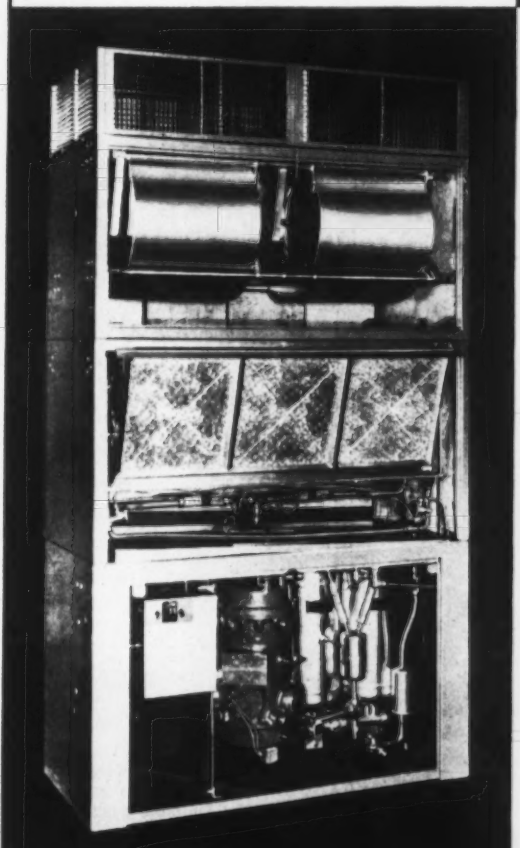
Welding Electrode for Hard Surfacing Steel

A new welding electrode for hard surfacing carbon steel and austenitic manganese steel parts is being marketed by McKay Co., 1005 Liberty Ave., Pittsburgh 22. Known as Hardalloy 44, the low hydrogen, consumable-type electrode is said to deposit a surface that resists extreme impact and severe abrasion.

The weld metal has an as-deposited Rockwell hardness of C40 to C45 on C1020 carbon steel plate and C33 to C45 on 12-14% manganese

WOLVERINE TUBE HELPS

CHRYSLER "CREATE CLIMATE FOR LIVING WHEN NATURE DOESN'T"



CHRYSLER PACKAGED AIR CONDITIONER

Suction lines. Capillary tube. Light wall special temper tube. Finned tube and plain. All these Wolverine products have important places in the evaporative and condensing units which are the hearts of Chrysler air conditioning systems. You'll find Wolverine products in most Chrysler units.

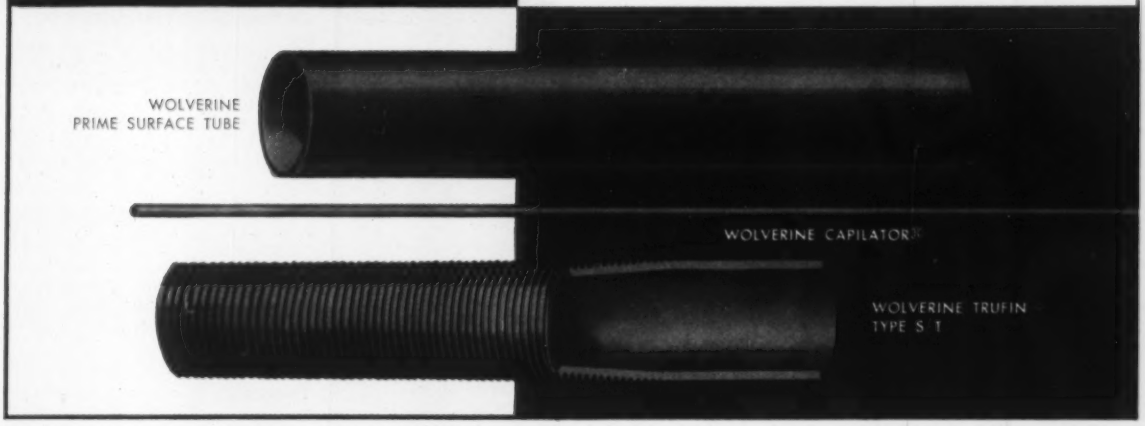
Chrysler is famous for firsts in air conditioning research and development, just as Wolverine has paced the field in pioneering tubing ideas and products to serve the industry. Important Wolverine developments for all industries include Wolverine Trufin®, the integral finned tube; Wolverine Capilator®, the capillary tube for precision metering of liquids and gases, and light wall special temper tubing.

When you specify Wolverine seamless copper, copper alloy or aluminum tube—you are cashing in on the high quality and outstanding service that only experience can give. Write for complete information as to how Wolverine can help you. Do it now.

WOLVERINE TUBE
DIVISION OF
Calumet & Hecla, Inc.
DEPT. E, 17258 SOUTHFIELD RD., ALLEN PARK, MICH.
Manufacturers of Quality Controlled Tubing

PLANTS IN DETROIT, MICHIGAN AND DECATUR, ALABAMA
SALES OFFICES IN PRINCIPAL CITIES

J-8969



For more information, turn to Reader Service card, circle No. 481

it's DELRIN*

You get metal-like properties in these new, plastic, prevailing-torque lock nuts: excellent strength, rigidity and dimensional stability.

Recommended for light metal assemblies, toys and similar fastening . . . they can save about half the cost of aluminum lock nuts.

Available in #10 and ¼" sizes, the RB&W open end acorn nuts have holding strength of 500-700 lbs in straight tension. Prevailing torque (a measure of its locking) is 8-10 in-lbs for the #10; and 12-15 in-lbs for the ¼". The nut forms its own thread. Pigmented gray is standard; other colors available in production quantities. Reusable. Send for samples.

Ask about other sizes and styles . . . and other parts custom molded from Delrin or other thermoplastics in production lots.

Write Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, New York.

*DuPont trademark

R B & W
116th year

For more information, circle No. 454

What's new IN MATERIALS

plate. Although deposits are not machinable, they are smooth and sound, requiring a minimum of grinding.

The product is recommended for overlaying dredge pump impellers, bucket lips and teeth, hammer mill hammers, augers, bulldozer blades, paper break rolls, crusher screens, ditcher rollers and other parts.

The electrodes are supplied in 5/32, 3/16 and ¼-in. dia in standard 14-in. lengths. They are also supplied in 5/16-in. dia in 18-in. lengths. According to the developer, each pound of electrode covers approximately 25 sq in. of metal with a ⅛-in. thick coating. KEY NO. 617

Instrument Grease Used from –75 to 300 F

A new synthetic grease is designed specifically for instrument applications over the temperature range –75 to 300 F. It is available from Lehigh Chemical Co., Chestertown Md.

Called Anderol L-793, the material is a lithium soap grease that uses a medium viscosity diester oil as a base fluid. The product, said to have built-in rust protection, is recommended for lubricating precision bearings, pneumatic and hydraulic systems, clocks and watches.

The grease is said to offer penetration comparable to that of the finest penetrating oils. Nongumming and stable, the grease leaves no harmful deposits on precision parts, according to the developer. KEY NO. 618

Two Insulations for Electrical Applications

Spaulding Fibre Co., 310 Wheeler St., Tonawanda, N. Y. has introduced two new insulating materials for use in electrical devices. One insulation, HT 50, is supplied in sheet form, and the other, No. 800, is supplied in rod form.

HT 50 sheet is said to permit higher thermal overloads in oil-filled transformers with no sacrifice in insulation life. The material is said to remain inert in both standard and

Graphite Specialties Can Solve Difficult Problems

Custom grades of graphite are regularly formulated by Graphite Specialties Corp., and furnished in extruded, molded and machined shapes to close tolerances to meet a wide range of difficult applications . . . *OR* GSC may be able to provide one of their many existing formulations to meet your requirements.

GRAPH-I-TITE: A collection of unique properties in one material, so valuable for such a wide diversity of uses, that GRAPH-I-TITE is furnished in two grades in standard sizes of rod and tube, as well as machined shapes. GRAPH-I-TITE possesses uniform high density . . . low permeability . . . immunity to thermal shock . . . resistance to corrosion at extremely elevated temperatures . . . and is not wetted by molten metals.

CARBO-TITE: Similar to "Graph-i-tite" except a carbon, rather than graphite base, and Carbo-tite is as hard as glass, and features a relatively *low* rate of thermal conductivity.

NUCLEAR: Purity grades to specified density for lowest neutron-capture cross section; highest scattering cross section for moderator, fuel elements, structural parts and piping and related equipment.

METALLURGICAL: Custom shapes and grades of graphite for special molds, dies, crucibles, boats, etc., for the chlorination of metals and other difficult applications.

MISSILES & ROCKETS: Recent developments make special grades of graphite particularly promising for nose cones, rocket nozzles and similar high temperature, high erosion applications.

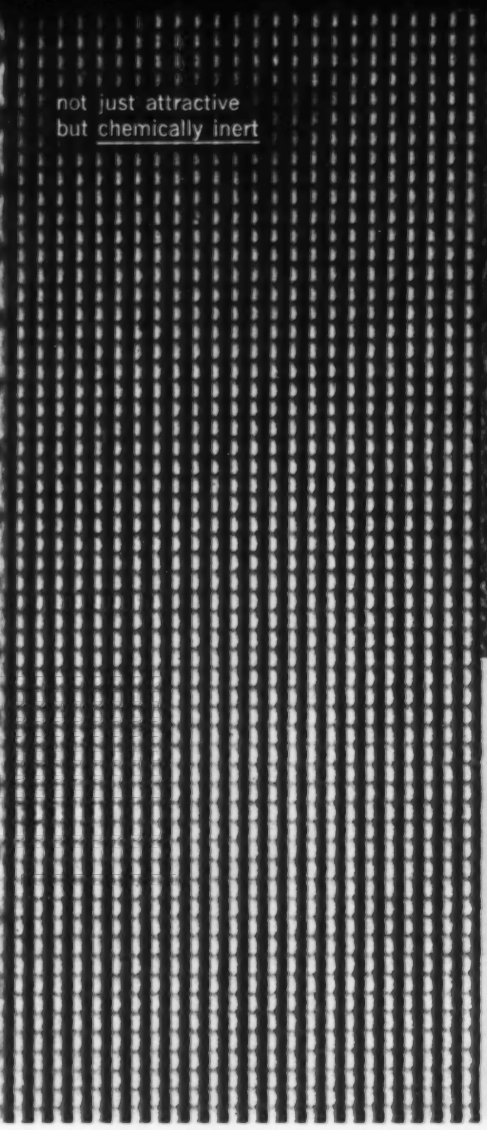
MECHANICAL: Grades available with specified properties including temperature resistance to 5700°F., hardness to 5 + Mohs for bearings, seal rings, seats, etc.

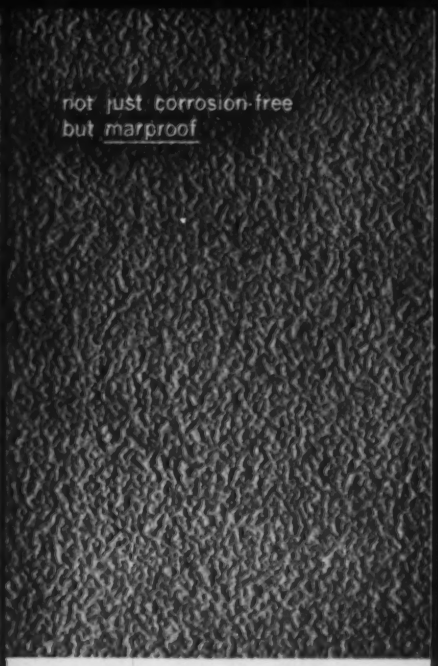
FURNACES: In addition to graphite components for resistance and induction furnaces, Graphite Specialties Corp. designs, manufactures and installs complete ultra-high temperature furnaces for heating requirements as high as 5700°F.

CHLORINE HEATERS: Special furnace development has led naturally to manufacture of what is believed to be the first practical type of chlorine heater for any temperature requirement to 5700°F.

Write to GRAPHITE SPECIALTIES CORP., 64th & Pine Ave., Niagara Falls, N. Y.

For more information, circle No. 382





You can have your pattern and protect it, too ...with M&T Spray-on Vinyl Finishes

A THICK-FILM SPRAYED-ON VINYL FINISH that mirrors the pattern of metal underneath . . . or which can itself be textured chemically . . . this is the exciting news in product finishes from M&T.

Now, you can choose any available mill patterned metal, confident that its distinctive profile will not be obscured by the coating. Clad with a thick-film M&T vinyl finish, the product will look richer, feel warmer, last longer.

This finish will stay free from unsightly blemishes such as chipping, corrosion, marring, stains and fading. Its resistance to abrasion is as much as ten times greater than that of ordinary textured enamels. Typical use: business machine housings.

These spray-on vinyl finishes apply even on intricate shapes, and at the *end* of the production operation. Thus, they create no problems in forming or welding, leave no raw edges. Moreover, you can change colors anytime without creating an obsolete inventory. Send for more data.

M&T **coatings and finishes**
METAL & THERMIT CORPORATION
General Offices: Rahway, New Jersey

For more information, turn to Reader Service card, circle No. 412

Easy Operation, Precision Measurements ...with Wilson "Rockwell" Hardness Testers

• No matter what your hardness testing requirements are, there's a Wilson Rockwell instrument to do the job easily and accurately. Long recognized as the world's standard of hardness testing accuracy, Wilson instruments on the production line and in the laboratory offer these advantages:

Accuracy—Each instrument is precision-built, with exact calibration, for consistently correct results.

Easy operation—Even an unskilled operator can get perfect readings. All controls conveniently grouped.

Long life—Simple design, rugged construction make Wilson instruments as durable as a machine tool.

Easy maintenance—Interchangeable mechanisms, with spindles mounted in oil-less bearings.

Complete line—Choose from the widest variety of instruments available, including semi and fully automatic models.

Wilson "Brale" Diamond Penetrators Each diamond is cut to an exact shape. A comparator check and microscopic inspection of each diamond assure perfect readings every time.

Write for details—Ask for Catalog RT-58. It gives complete information on the Superficial tester as well as on the full line of Wilson Rockwell hardness testers.

WILSON "ROCKWELL" HARDNESS TESTERS

ACCO

Wilson Mechanical Instrument Division
American Chain & Cable Company, Inc.
230-E Park Avenue, New York 17, New York

For more information, turn to Reader Service card, circle No. 479

What's new IN MATERIALS

inhibited transformer oils. It is comparable to standard insulating materials in oil absorption, formability and other properties.

KEY NO. 619

No. 800 rod is said to maintain unusually high dimensional stability under conditions of high moisture. The product, supplied in either linen or paper-base grades, is being used for insulating pins in the temperature control dials of electric fry pans and other small household appliances that come in contact with water. KEY NO. 620

Water-Base Adhesive Bonds Plastics, Wood

Rubbastix is the name given to a noninflammable, water-base adhesive that can be used for bonding polyethylene, polystyrene, vinyl, wood, foamed plastics, paper and fabrics to themselves and to other materials. It is available from Rubba, Inc., 1015 E. 173rd St., New York 60.

When dry, the adhesive is said to be waterproof and transparent. Applied by brush or spray, it dries in 30 min at room temperature and in 4 min under hot air or infrared heat. KEY NO. 621

New Stainless Steels Have Good Weldability

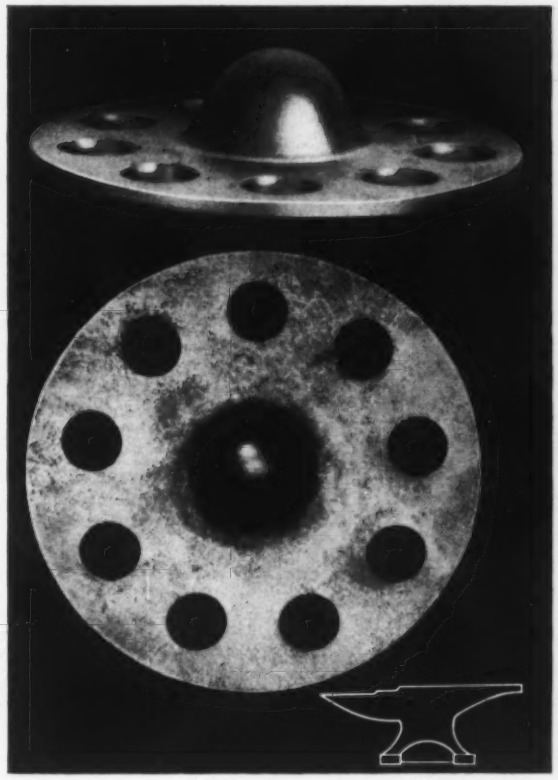
A new group of stainless steels, described as high strength, highly ductile and super weldable materials, is being developed by scientists at Westinghouse Electric Corp., Box 2278, Pittsburgh 30.

The steels have been used to make welding rod and parts for laboratory vacuum systems. But Westinghouse scientists predict that the new steels, called Kromarc, will soon find their way into larger and more complicated structures which, for design purposes, must be fabricated from stainless steel.

The design of the weldable steels was discussed by F. C. Hull, advisory metallurgist at the company's research laboratories, at a recent ASTM meeting.

The basic composition he chose for study was an austenitic stainless

RITCO FORGINGS



...their strength alone merits your design consideration!

Forged-in toughness which assures dependable impact resistance at points of greatest shock and stress is, in itself, a sound recommendation for the use of Ritco Forgings. Their dense, fibrous structure and controlled grain flow provide maximum fatigue strength . . . still another important factor in their favor. Combine these with close-tolerance accuracy and flawless finishes which speed up parts assembly and it's easy to see why Ritco Forgings are being written into more and more product designs. *All* things considered, it will pay you to write them into yours, too. Send us your blueprints for estimates at no obligation.

Ritco also offers complete machining facilities and makes Special Fasteners and Upsets of ferrous and non-ferrous metals. What are your requirements?

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Replace Metal Trim!

Self-Adhesive Fasson Mylar* Vinyl Laminates in Rolls, Sheets or Strips

Replace expensive stampings, die castings and extrusions! Save on tooling costs! Fasson Mylar Vinyl Laminates can be obtained in rolls, sheets or strips, whichever you prefer. They can easily be cut to the desired width or length.

Choose from a wide range of beautiful metallic finishes in a variety of embossed patterns. Mylar Vinyl Laminates resist shock and abrasion . . . won't tarnish or turn dull.

And because Fasson Mylar Vinyl Laminates are self-adhesive, you save on the assembly line. They are applied merely by peeling off the backing paper and pressing into place. No skills or special tools are needed. No tapping, riveting or fasteners of any kind. Fasson's adhesive sticks tighter with time.

Investigate their cost-saving advantages. Write today for samples and prices.

*Mylar is a DuPont Polyester Film

fasson

Fasson Products
A Division of Avery Adhesive Products, Inc.
250 Chester St., Dept. T-9, Painesville, Ohio

For more information, turn to Reader Service card, circle No. 369

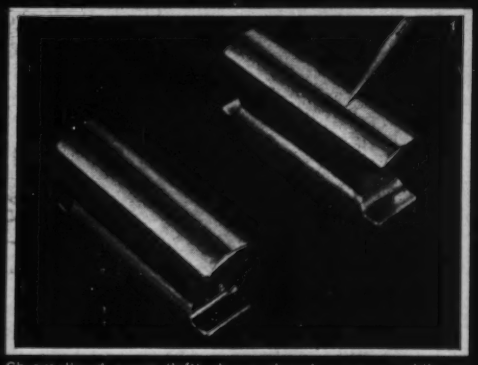
High Carbon Steel

wears almost III times longer when

CHROMALLIZED

HERE IS POSITIVE PROOF

In a test conducted by the Formsprag Company of Warren, Michigan, CHROMALLIZED sprags were removed from an automobile transmission after 55,000 miles of use and compared with ordinary sprags from another transmission after 33,000 miles of use. The CHROMALLIZED sprags showed less than half the wear of the other sprags.



Chromallized sprag (left) shows almost no wear, while an ordinary sprag shows considerable wear.

WHAT IS CHROMALLIZING?

A proven process of diffusing Chromium with other elements into the surface provides an alloy case which is integral with the base metal. It can't peel or flake; the chromium and other elements diffuse uniformly into recesses, pores, cracks and even blind holes. CHROMALLIZING provides not only resistance to wear but also considerable resistance to corrosion and oxidation.

This process may be applied to superalloys and refractory metals for high temperature oxidation resistance.

WRITE FOR ILLUSTRATED BULLETIN M.S.

Chromalloy corporation

169 Western Highway • West Nyack, N. Y.
ELmwood 8-5900

CHROMIZING CORPORATION, LOS ANGELES, CALIFORNIA
PROPELLEX CHEMICAL DIVISION, EDWARDSVILLE, ILLINOIS
Propellents, cartridge actuated devices, explosives and special chemicals.
ELYRIA FOUNDRY DIVISION, ELYRIA, OHIO. Quality gray iron castings.
SINTERCAST DIVISION, YONKERS, N. Y. Machinable carbides & nuclear materials.

For more information, turn to Reader Service card, circle No. 345

steel containing 16% chromium and 20% nickel. Hull studied the effects of chromium and nickel as well as the effects of 16 additional alloying elements on the hot cracking tendencies of stainless steel.

Manganese decreases hot cracking

The study showed that substantial amounts of manganese decrease the hot cracking susceptibility of stainless steel, thereby increasing weldability. Molybdenum and tungsten also improve resistance to hot cracking, but vanadium is essentially neutral in its effect.

On the other hand, Hull found that titanium and columbium, two elements frequently added to high strength stainless steel, promote hot cracking. So also do boron, zirconium, silicon and copper.

On the basis of these test results, the Westinghouse scientist says that manganese content should be much higher than that normally used in chromium-nickel steels to obtain a material with good welding characteristics.

Honeycomb Core Is Heat Resistant, Strong

A new type of nonmetallic honeycomb core for high temperature applications has been developed by H. I. Thompson Fiber Glass Co., 1733 Cordova St., Los Angeles 7.

The product, called Hitcomb, is made by a three-dimensional weaving process (details not disclosed), resulting in a honeycomb structure having square cells (see accompanying photo).

Core has high strength

Thompson officials say that the most important characteristic of the product is its square cells which demonstrate nearly isotropic shear properties. According to them, "Hitcomb honeycomb core exceeds the temperature limitations of bonded node cores because of its woven nodes." Tests show that a woven fiberglass core exceeds all physical property requirements of specification MIL-C-8073A.

The core, supplied in fiberglass or in a silica-type insulating material

(continued on p 244)

ALUMINUM

in stock at
FRASSE

Regardless of grade, shape or size ...it's likely the aluminum you want can be shipped *immediately from stock by Frasse*. Frasse aluminum inventories are at an all-time peak —every pound of dependable quality... produced to rigid standards by Reynolds.

And, if you wish—Frasse aluminum specialists will gladly help with grade selection... or prescribe the most economical method of fabrication. You'll like the *fast delivery*... the *uniform quality*... and the *careful handling* your aluminum orders receive at Frasse. Call us whenever you need aluminum.

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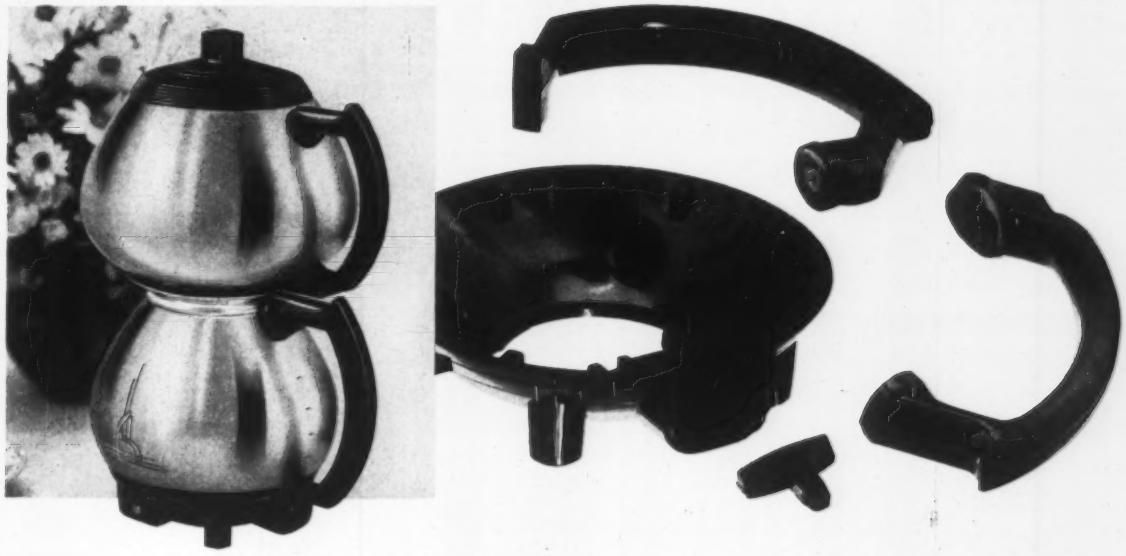
For more information, turn to Reader Service card, circle No. 493

Molded Vinyl Provides Flexibility and Color Harmony in Steering Wheel Grommet. Color matching without painting, flexibility as needed—these are two advantages BAKELITE Brand vinyl offers in these grommets for Mercury cars. Used to enclose the steering column at the instrument panel, the grommets are molded in colors to harmonize with car interiors. Flexibility of the vinyl permits the grommet to fit snugly and eliminate road vibration. A cost saving over the rubber used previously was another important advantage.

FOR A FRESH NEW LOOK,

Colorful High-Impact Styrene's Light Weight Makes This Portable Sewing Machine Easier to carry. Durability and a pleasing appearance enhance the sales appeal and service life of the carrying case for Singer's new portable sewing machine. The BAKELITE Brand high-impact styrene plastic cut four pounds from the weight of the old-type case, and gives a high-gloss finish in lasting color. Moldability of the BAKELITE high-impact styrene proved best of several plastics tested before production began. Matching base and accessory box are molded from the same material.



Phenolics Improve Looks and Service Life of an Automatic Coffee Maker. Main considerations in the design of this utensil were attractive appearance and heat resistance. BAKELITE Brand phenolics met both requirements at low cost. Base, handles, and upper rim were molded from phenolic resins developed by Union Carbide Plastics Company. They don't warp or blister and keep their lustrous finish even though frequently exposed to hot fumes and coffee grounds.

REDESIGN IT IN PLASTIC

When your product must be handsome as well as efficient, molded plastic components can give it fresh eye-appeal and durability that influence buyers

Is the sale of your product hampered by an unattractive or outmoded appearance? Then start anew, and design it freely, according to your ideas of what it could look like.
You have more freedom when your design calls for fabrication with BAKELITE Brand plastics. Choose from numerous BAKELITE Brand plastics—polyethylenes, epoxies, phenolics, styrenes, and vinyls—all are high quality, and offer you a wide range of properties. You can get colors, impact strength, heat and ultraviolet resistance, light weight; plus the fabricating characteristics you need. And more than likely you'll realize a cost saving besides.

See your Sweet's Product Design File, Sec. 2a/ui for properties of BAKELITE Brand plastics. For specific information, just mail the coupon.

BAKELITE and UNION CARBIDE are registered trade marks of Union Carbide Corporation.

UNION CARBIDE

Dept. DE-85,
Union Carbide Plastics Company
Division of Union Carbide Corporation
270 Park Avenue, New York 17, New York

Please send me details about BAKELITE Brand plastics for molding applications. Application being considered is

NAME_____

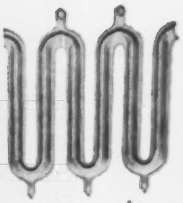
FIRM NAME_____

STREET_____

CITY_____ ZONE____ STATE_____

For more information, turn to Reader Service card, circle No. 501

SHELL MOLDED PARTS



corrosion resistant

heat resistant

abrasion resistant

DURASHEL

- *accuracy*
- *superior finish*
- *cut machining*
- *low cost*

We are equipped to help you pick the right alloy for planned service conditions...We are equipped to help you design your part to take advantage of the possibilities of shell molding...We are equipped to manufacture high alloy, shell molded parts to your specifications in quantity and on time!

We suggest you check on shell molding for your high alloy casting requirements. Write us today for additional information.

The DURALOY Company

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CHICAGO OFFICE: 332 South Michigan Avenue
DETROIT OFFICE: 23906 Woodward Avenue, Pleasant Ridge, Mich.

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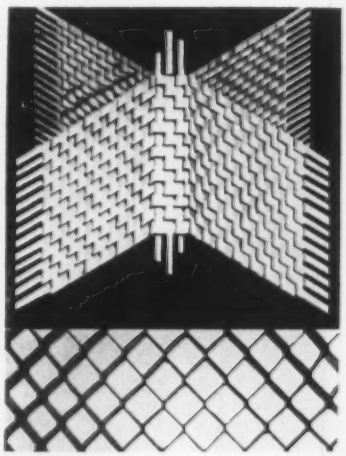
What's new IN MATERIALS



Cross-sectional view *(above) shows how node of new honeycomb core is woven together to form a structure with square cells (below).*

called Refrasil, can be combined with such resin systems as phenolics, phenyl-silane, silicones, polyesters and epoxies. **KEY NO. 622**

Solid Film Lubricants

Three new solid film lubricants have been placed on the market in recent months. Although used for similar applications, each lubricant has its own chief characteristic. One dries in air, another is a water-base type that has good stability, and the third has good resistance to radiation.

1. Air drying type

The air drying solid film lubricant is available from Hohman Plating & Mfg. Co., 814 Vermont Ave., Dayton 4, Ohio. Called Surf-Kote A-1290, the material is said to provide a hard, durable solid film lubricant on most types of metal surfaces.

It is said to have a low coefficient of friction over a wide range of pressures, temperatures and surface speeds, preventing galling, seizing, fretting corrosion, cold welding and similar friction problems.

Recommended for lubricating inaccessible surfaces, Surf-Kote A-1290 is particularly well suited for field application on heavy machinery and parts too large for curing ovens.

The product is also recommended

BOND FAILURES CAN BE PREVENTED!

Here's how to stop 13 of them...

Type of Failure	Solution
THERMOSETTING ADHESIVES	
• Cohesive failure	Check film with solvent used in adhesive. If solvent softens the adhesive film or becomes tacky, this indicates insufficient cure. Make sure bond line time and temperature is used.
• Adhesive failure from metal	If metal surface has a white, clean appearance, check cleaning technique.
• Adhesive failure from substrate other than metal	Try prime coat of diluted adhesive, also check compatibility.
• Cellular areas in adhesive line	Increase pressure and/or adhesive.
CONTACT ADHESIVES— room temperature setting	
• Tacky film	If film should dry hard but remains tacky, the cause may be entrapped solvent or migration of plasticizer from one substrate.
• Shiny areas	Poor contact, insufficient pressure or insufficient amount of cement.
• No bond	If heat reactivated type, adhesive was too cool at time of assembly or poor compatibility.
• Failure in adhesive from metal	Improper cleaning.
• Failure from substrate other than metal	Incompatible or unclean surfaces.
HOT MELT	
• No bond	Incompatibility, adhesive too cool at time of assembly. Parts too cool at time of application of adhesive.
EPOXY BASE ADHESIVES AND CASTING COMPOUNDS	
• High exotherm	Mix lower volume and pour mixed material into shallow tray. Cool base and activator before mixing or use Metermixing equipment.
• Tacky film or casting	Improper base activator ratio, improper mixing of base and activator, improper cure. Check bond line temperature.
• Flexible casting or film of rigid adhesive or casting compound	Improper mixing of base and activator, improper base and activator, improper cure. Check bond line temperature.

Bond failures can be prevented! Raybestos-Manhattan's adhesive experts also have solutions to less common causes of bond failures . . . based on more than 20 years' experience in the production of bonded assemblies and the manufacture of adhesives, coatings and sealers. Why not call on them today for the answers to your adhesive problems—no cost or obligation, naturally.

R/M Bulletin No. 700 is packed with helpful technical information on Ray-BOND adhesives. Write for your free copy now.

RAYBESTOS-MANHATTAN, INC.

ADHESIVES DEPARTMENT, Bridgeport, Conn. • Chicago 31 • Detroit 2 • Cleveland 16 • Los Angeles 58

RM

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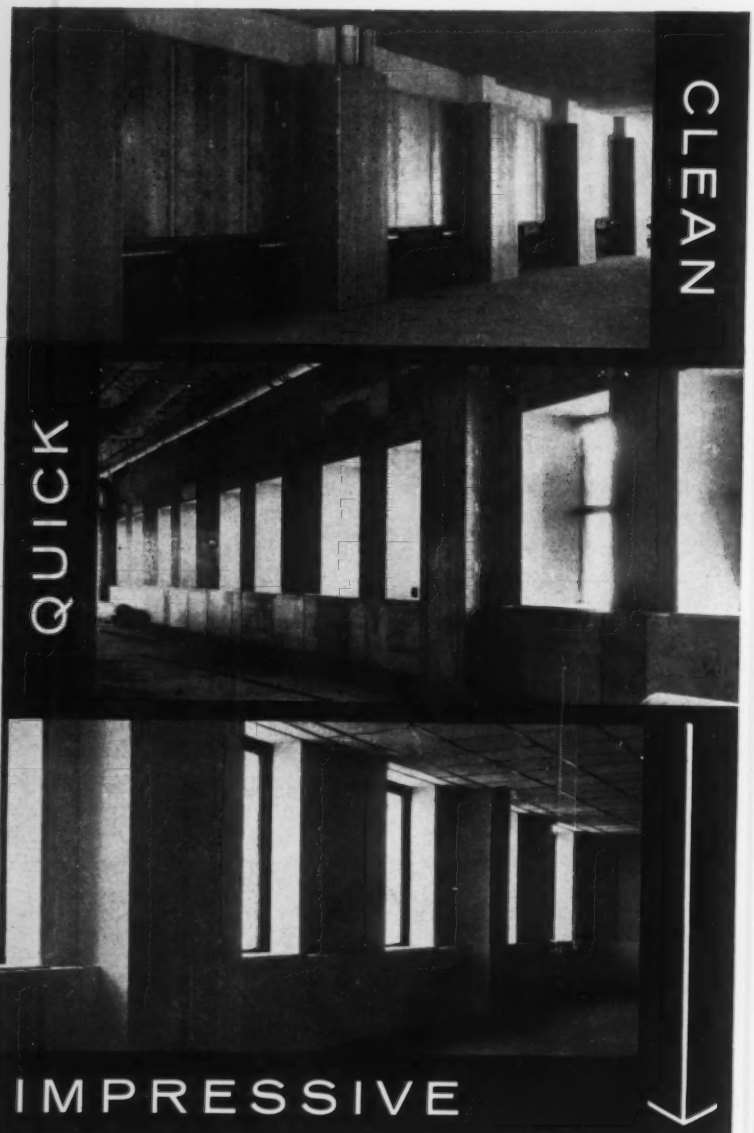

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Durable, Beautiful Structural Laminates

Wall Panels • Pipe and Column Enclosures • Convector Covers

Your uses of Met-L-Wood provide basic satisfaction from initial planning clear through years-later "thank you's" from building maintenance crews. Quickest way to get acquainted with Met-L-Wood possibilities on your projects is to look over Met-L-Wood Architectural Bulletin 591. Met-L-Wood development and engineering brains are ready to help, too. Write for Bulletin 591 now.

Progressive installation photos from Vulcan Building, Cleveland, Ohio. McDowell Company acted as its own general contractor and Hubbell & Benes and Hoff, Inc. were associate engineers and architects.

See our catalog in Sweet's Architectural File—14a/Me

MET-L-WOOD CORPORATION

6755 West 65th Street • Chicago 38, Illinois

For more information, turn to Reader Service card, circle No. 413

for use as a protective coating. The producer says parts coated with the material can be stored outdoors without fear of rust or corrosion from weathering. KEY NO. 623

2. Stable water-base type

The water-base type lubricant is marketed by Acheson Colloids Co., Div. of Acheson Industries, Inc., Port Huron, Mich. It is called 'dag' dispersion No. 206.

Providing good stability and shelf life, the lubricant does not tend to become highly acidic, a common occurrence with some dispersions of molybdenum disulfide in water. The new lubricant, processed from specially refined molybdenum disulfide, is said to resist settling.

Potential uses include: mold coating, forging lubricant, wire drawing lubricant, gasket coating and high temperature lubricant. KEY NO. 624

3. Radiation resistant type

Electrofilm, Inc., 7116 Laurel Canyon Blvd., North Hollywood, Calif. says it has developed and perfected specific solid film lubricants that "operate without deterioration when exposed to nuclear irradiation from 1×10^7 r to 1×10^9 r at temperatures up to 550 F." The developer says wear life properties of the lubricants (compositions not disclosed) are actually increased by over 30% after exposure to nuclear irradiation.

The lubricants are said to lubricate efficiently over the temperature range -65 to 1800 F. KEY NO. 625

Oil-Filled Nylon Holds Oil Under Pressure

New microporous nylon parts that absorb 15 to 50% of oil by weight are now available from Polymer Corp., 2120 Fairmont Ave., Reading, Pa.

The oil-filled nylon parts are claimed to retain the oil under extremes of pressure, temperature and acceleration. They also retain nylon's inherent abrasion resistance and nongalling surface characteristics.

Parts made by cold pressing, sintering

The nylon parts, known as Nylasint 64HV, are formed by cold pressing and sintering specially

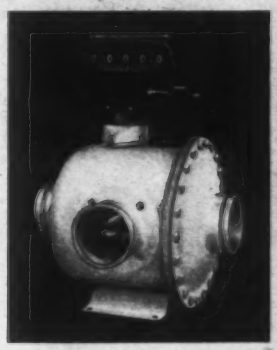
Kanigen®

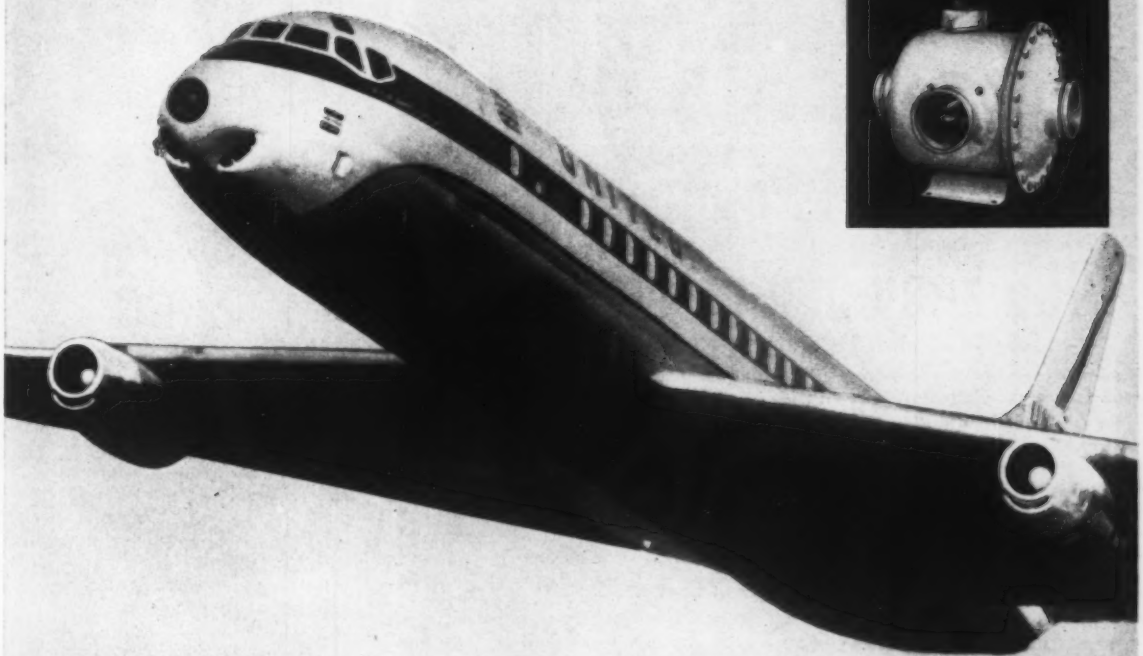
helps keep jet aircraft where the money is ...in the air

Big jet aircraft make money only when they are in the air. Every minute they are earthbound is costly. You just can't take chances on failure of aircraft engines from fuel contamination, or on failure of refueling equipment. That's why those parts of Brodie BiRotor refueling meters and control valves that come in contact with the fuel are chemically plated with KANIGEN nickel alloy.

Brodie BiRotor meters have been used for controlling aircraft refueling for many years, and their internal parts have been KANIGEN-coated ever since this highly accurate method of plating difficult or complicated surfaces was perfected.

Do you have a corrosion or contamination problem? Is it a small part like the Brodie meter housing? Or is it a surface as large as the inside of a 20,000 gallon tank car? Whatever it is, there's a way to solve your problems with KANIGEN chemical nickel plating. Write or phone the nearest General American office. *It pays to plan with General American.*





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For more information, turn to Reader Service card, circle No. 375

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Hackney forming methods produce strong, lightweight, seamless shells the cold drawn way. With smooth, clean surfaces, consistently uniform side walls and closely controlled tolerances, performance reliability becomes an integral part of every Hackney deep drawn shape or shell.

You will find plenty of design latitude in our methods because we make available to you a vast assortment of dies, mandrels and related tooling to match your ideas. Units can be made in sizes from 1 qt. to 100 gal. Diameters range from 2" to 32". Lengths may be from ½ to 5 times the diameter, or up to 110"...working pressures to 10,000 psi, depending on diameter.

Hackney experience and facilities can form your components in steel, magnesium, nickel, ultra-high-strength stainless steels, hot work tool steels, molybdenum or titanium. Let our engineers help you work out details and suggest ways to improve reliability...reduce cost. For complete information, write to the address below:

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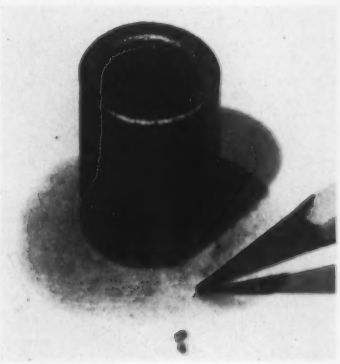
What's new IN MATERIALS



Oil retention *of microporous nylon (above) is compared to that of oil-impregnated bronze (below). Both bearings, with approximately 25% oil by volume, were placed on paper stock for 72 hr. The oil-impregnated bronze part lost considerably more oil (as indicated by dark area around base) than the nylon part.*

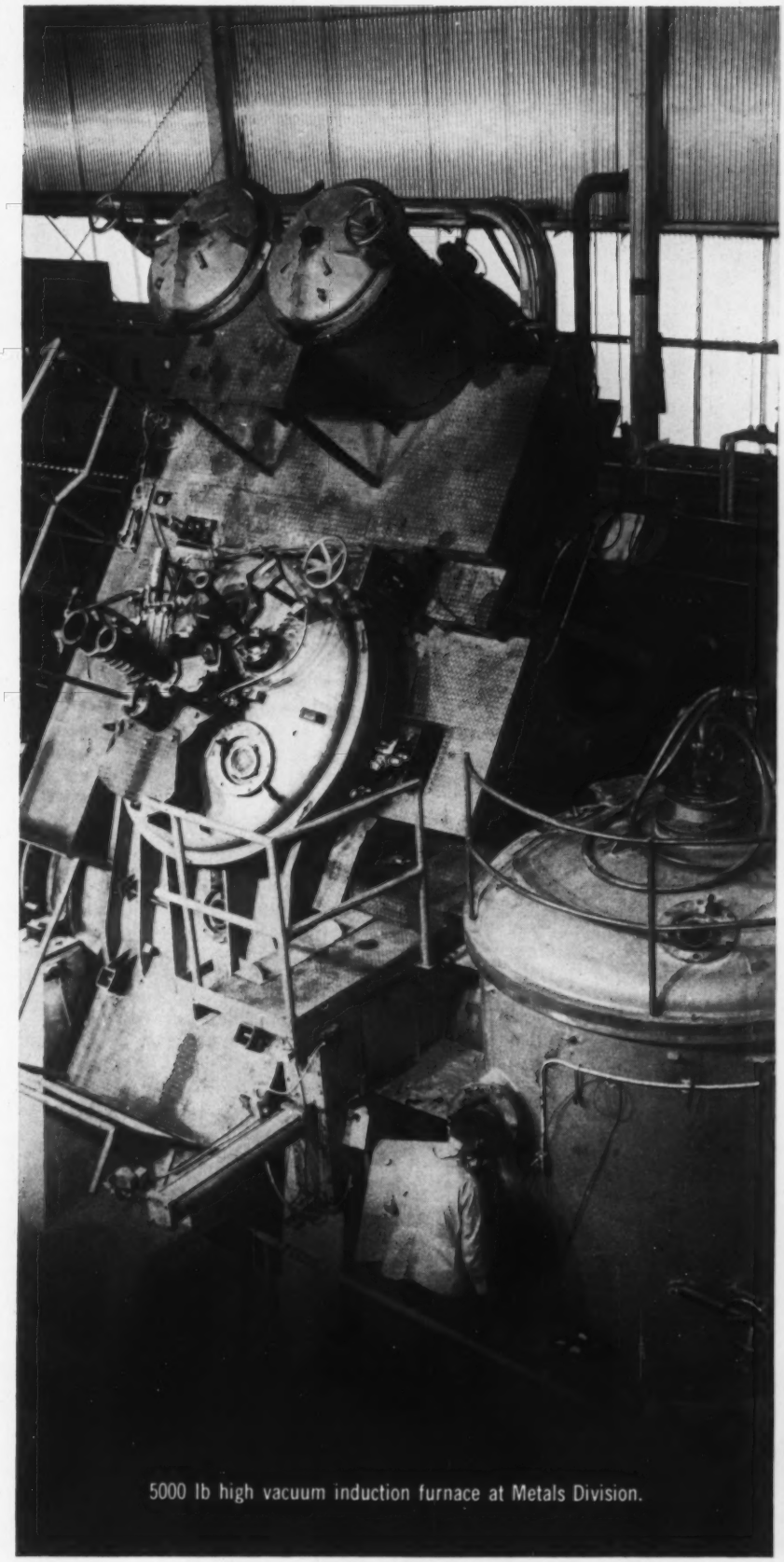
processed nylon powders by techniques similar to those used in powder metallurgy.

The parts are said to operate for long periods at a frictional coefficient as low as 0.01; conventional oil-filled metallic bearing materials lose their lubricating properties faster under the same conditions.

Potential applications

The producer says the nylon parts will probably find use as bearings and wear parts in applications where low frictional lubricated surfaces must be maintained over indefinite periods without subsequent lubrication.

The unique fluid retention properties of the microporous product have also resulted in other new ap-



5000 lb high vacuum induction furnace at Metals Division.

Are you after highest alloy properties in heat-after-heat?

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Highly reactive elements enhance high-temperature alloy properties. Today, only one production metal refining process can effectively control the action of these elements, and—heat-after-heat—meet the most exacting alloy specifications.

The process is vacuum induction melting, and the only specialist in this process is the Metals Division, Kelsey-Hayes Company.

In a specially designed plant which contains seven vacuum induction furnaces with a monthly capacity of 1 million lb, the Metals Division produces over 50 alloys for critical high-temperature, high-stress applications such as aircraft gas turbine buckets and wheels, missile and nuclear components. Alloys like Udimet 500 and 700 were developed by Metals Division. The Division is the leading producer of vacuum induction melted Waspaloy, M-252, and other alloys. Kelsey-Hayes Company, Detroit 32, Mich.

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What's new IN MATERIALS

plications. When filled with ink, for example, the parts are said to retain a large supply of ink which can be fed uniformly. KEY NO. 626

Improved Superalloy Is Strong at 1800 F

An improved cobalt-tungsten superalloy called WI-52 is now commercially available in both shot and ingot form from WaiMet Alloys Co., 5320 Oakman Blvd., Dearborn 2, Mich.

According to WaiMet, improved refining techniques and precise control of important alloying elements have increased 1800 F stress rupture life of the alloy by 18% and rupture elongation by 160% over previous alloy variations.

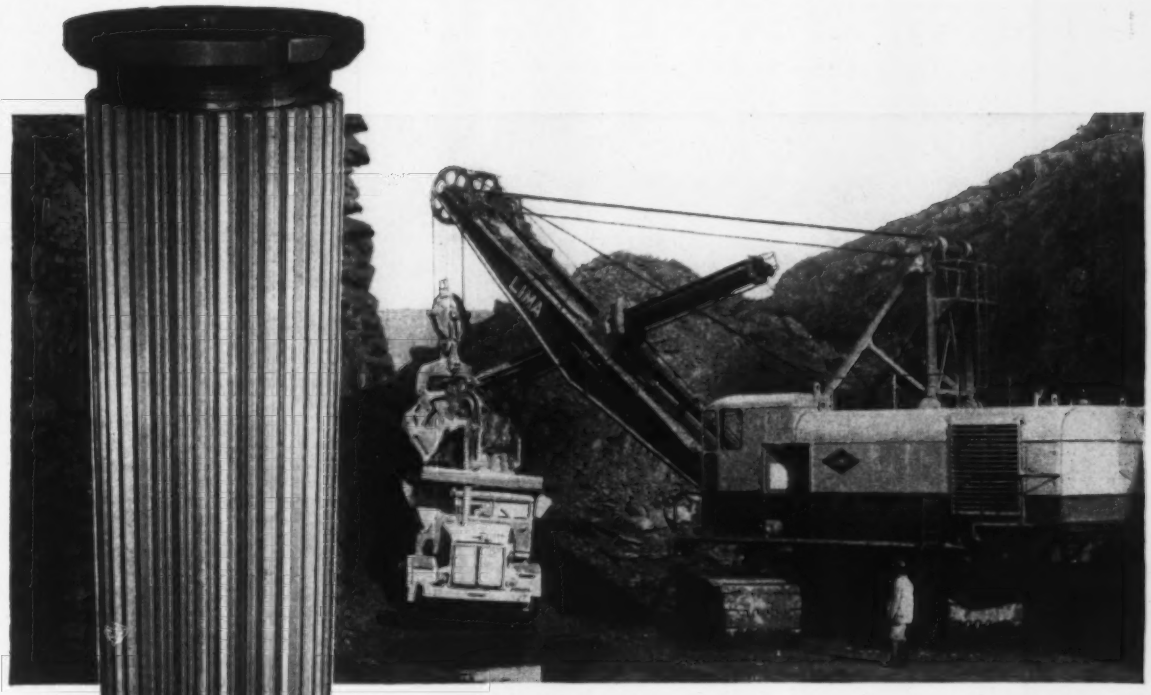
Present, potential uses

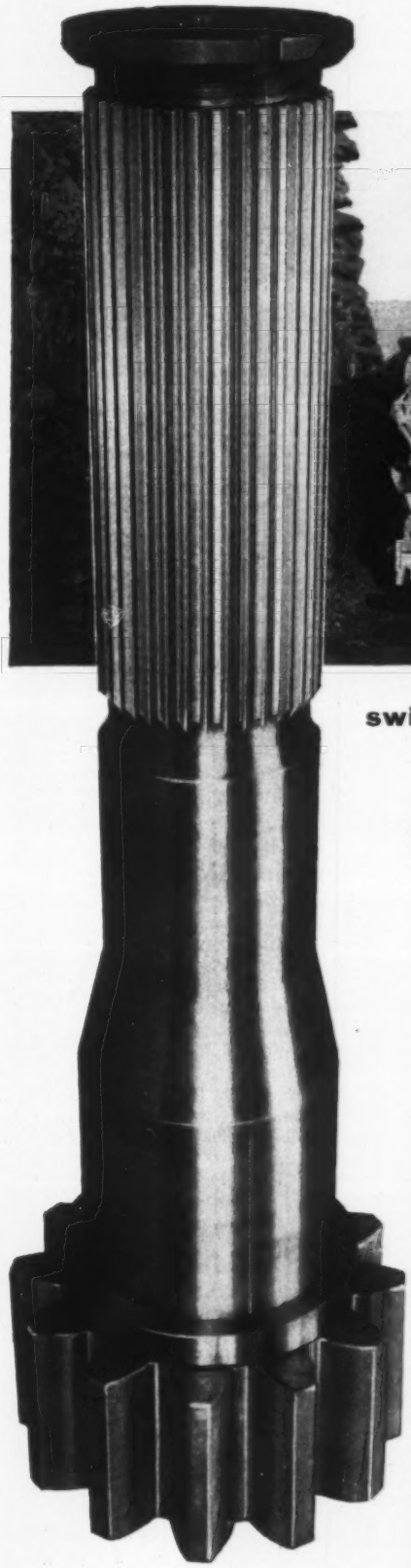
The air melted alloy has excellent castability and has been used primarily for investment-cast gas turbine parts, such as vanes and blades. Other applications for the improved alloy will probably include tools used in hot forming operations, brazing fixtures and furnace parts.

Alloy has longer rupture life than other cobalt-base alloys

The high temperature strength of the improved alloy is reported to be superior to that of other cobalt-base superalloys. Stress-rupture life is said to be at least 20% greater at 1800 F than that of X-40, the superalloy previously used for most

***Investment-cast vane** is made of improved cobalt-base superalloy.*





swing! stop! swing!

4340 nickel alloy steel takes shock-loading in stride

Every time the big Lima Type 2400 turns to dig or dump, this 9"-diameter, 36"-long swing shaft of 4340 nickel alloy steel transmits tremendous torque to a giant ring gear, to swing the rotating assembly smoothly and speedily.

Through-hardening 4340 nickel alloy steel gives this swing shaft the strength, the toughness, the uniform hardness, to stand up to hundreds of swing-stop-swing cycles every working day.

And because 4340 is readily machined at high hardness, both spur pinion and spline are machined on the shaft *after* heat treatment. The resulting one-piece component provides an extra measure of dependability; it permits splined mounting of gears on shafts with close, accurate fit, plus even distribution of shaft stresses.

For your medium-to-heavy section parts, you'll find 4340 nickel alloy steel delivers the high mechanical properties that make for trouble-free performance in the toughest service. Available right off the shelf at Steel Service Centers, this versatile through-hardening steel is ready for immediate delivery in a wide selection of sizes. Other nickel alloy steels, possessing special properties for specialized applications, are also widely available.

Next time you're faced with heavy wear and loading problems—such as in earth-moving equipment or motor-vehicle applications—remember Nickel alloy steels. *They can take it.*

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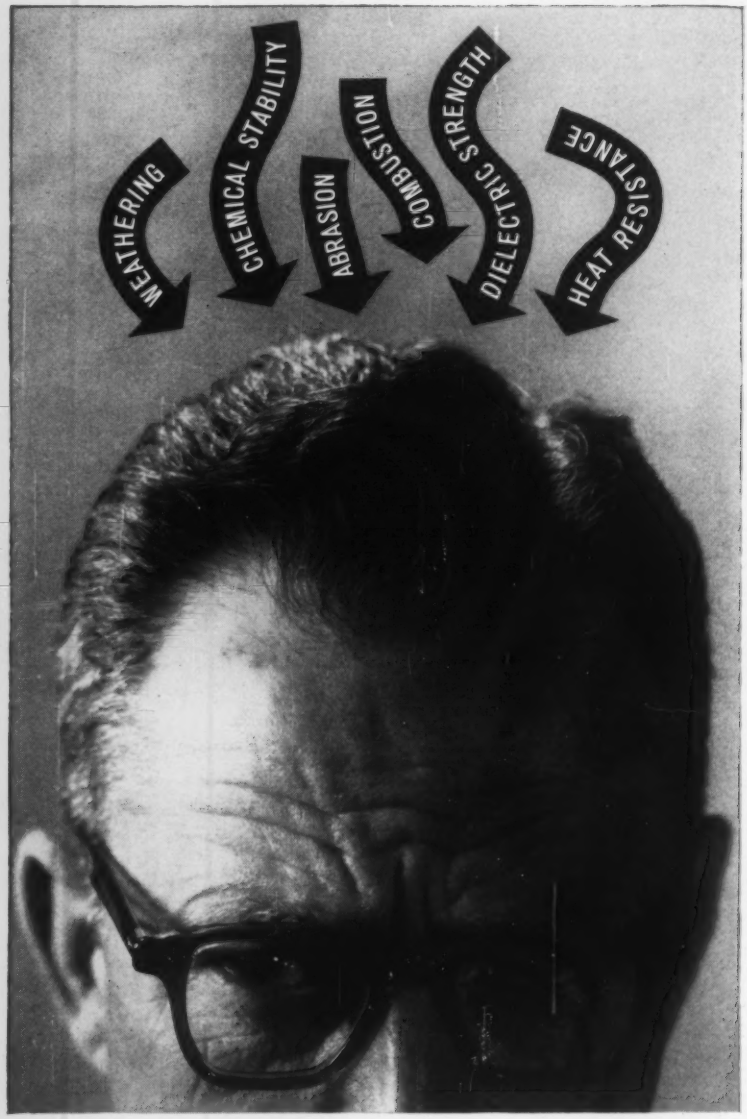

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COMPOSITION OF WI-52 (%)

Tungsten	10.00-12.00
Chromium	20.00-22.00
Carbon	0.40-0.50
Nickel	1.00 max
Iron	1.00-2.50
Columbium and Tantalum	1.50-2.50
Phosphorus	0.040 max
Sulfur	0.040 max
Manganese	0.50 max
Silicon	0.50 max
Cobalt	Balance

aircraft jet engine turbine blade and vane applications.

The improved alloy is also said to have good thermal shock resistance. For example, a turbine blade made of the alloy developed a deflection or blade bow of 0.010 in. after 100 cycles of heating at 2000 F for 2 min and cold air quenching for 40 sec. A blade made of X-40 alloy and exposed to the same conditions developed a deflection of 0.140 in.

KEY NO. 627

Modified Polypropylene Improves Coatings

A chlorinated polypropylene resin, called Parlon P, is claimed to be a desirable film-forming material for use in protective coatings, adhesives, paper coatings and flame retardant compounds.

Developed by Hercules Powder Co., Wilmington 99, Del., the new product joins the company's previously available chlorinated natural rubber called Parlon.

The new polymer, which is supplied in viscosities ranging from 5 to 125 cps, is equal to Parlon in chemical resistance, but has noticeably better heat and light stability.

Product contributes chemical resistance to coatings

Hercules says Parlon P in coatings is expected to contribute hardness; abrasion resistance; film integrity; and resistance to alkalis, acids, salt spray, moisture, mold growth, and heat and sunlight.

Compatibility, solubility

Compatibility of Parlon P with other resins does not appear to be as broad as that of Parlon, particularly with alkyds. However, Her-

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Also many other products, plus complete processing service, technical assistance.

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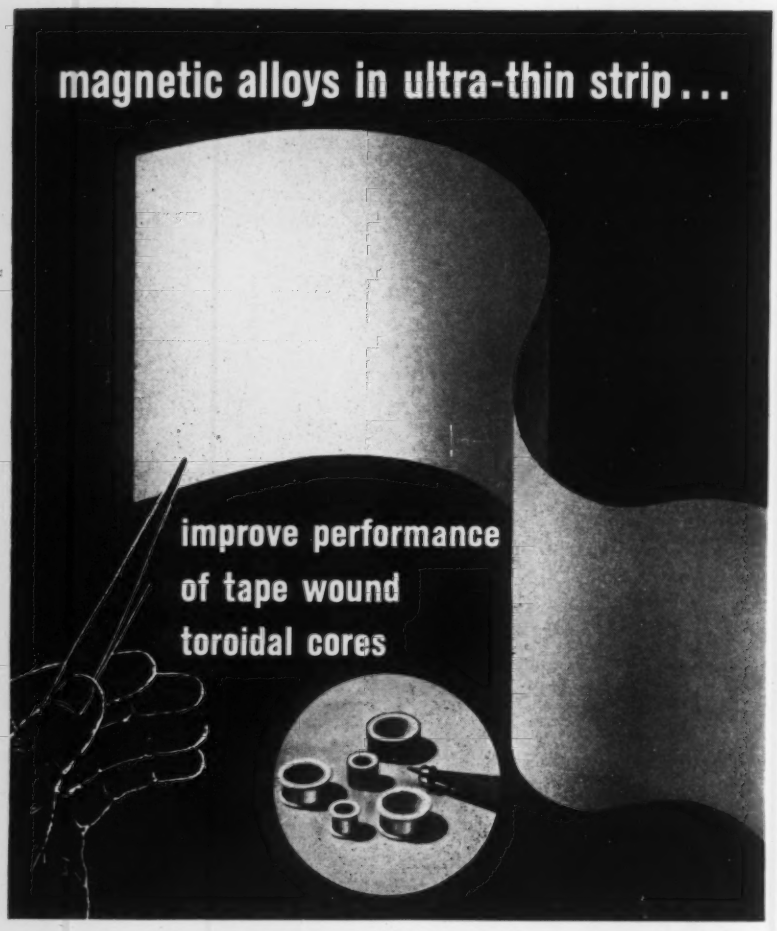

Toroids that generate lower heat and higher efficiencies and provide more uniform performance are another advancement made possible by ultra-thin magnetic alloy strip from Precision Metals. This unique material—now available in production quantities—can be supplied in virtually any of the high magnetic permeability alloys such as 4-79 Moly Permalloy, 50-50 grain-oriented nickel iron and Muvar®.

Precision Metals strip and foil is cold rolled in thicknesses from .010" to .0001" and can be furnished slit to tightest dimensional tolerances. Note these other important advantages:

uniform magnetic properties — **extremely close tolerances**
dimensional uniformity — **excellent surface characteristics**

To meet specific requirements, Precision Metals can furnish custom alloys to your specification in the form you need. Write today for fully illustrated facilities booklet DE-9.

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Regional Representatives
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cules says more work is being done on the subject of resin compatibility.

Tests show that chlorinated polypropylene is soluble in aromatic hydrocarbons, esters, methyl ethyl ketone and chlorinated solvents. It is not soluble in alcohols or aliphatic hydrocarbons. KEY NO. 628

Kel-F-Coated Fabric

Reeves Bros., Inc., 1071 Avenue of the Americas, New York 18 has added Kel-F-coated Dacron to its line of synthetic rubber-coated industrial fabrics.

The new product, called Reevecote, is intended primarily for diaphragms and gaskets in controls for aircraft, heating units and other equipment operating at high temperatures.

Limited property data show that 0.012-in. thick specimen of the material has a tensile strength of 200 psi and a Mullen burst strength of 320 psi. KEY NO. 629

Foams, Resins Are Self-Extinguishing

Developmental resins based on chloromethylated diphenyl ether have produced two new, self-extinguishing plastics materials. One is a low density foam and the other is a binder resin.

J. D. Doedens and H. P. Cordts, of Dow Chemical Co., Midland, Mich., reported the results of initial work with these materials at a recent meeting of the American Chemical Society.

Rigid insulating foams

Self-extinguishing, low density rigid foams produced with the resins are said to be strong and less friable than phenolic foams. The new foams will probably find use in sandwich panels, in thermal insulating panels, and in architectural applications such as roof deckings.

Foams with densities ranging from 0.5 to 8 lb per cu ft have been produced with either open or closed cell structures. Over this density range, compressive strengths range from 10 to over 100 psi. Thermal conductivity "k" factor ranges from 0.25

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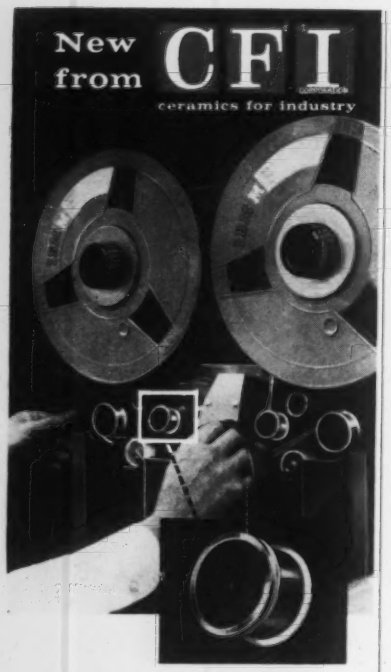


Ceramics To Solve Your Wear Problems

Problem: High-speed, oxide-coated magnetic tape is highly abrasive and causes excessive wear to tape guides. **Solution:** CFI, in cooperation with IBM engineers, developed ceramic tape guides made of wear-resistant CFI 696 Alumina. These new guides are hard, uniform and possess a relatively low coefficient of friction. **Result:** Excellent wear characteristics have been demonstrated for more than a year in this critical application.

CFI 696 Alumina provides other important advantages such as a dense, fine-grained structure, chemical- and thermal-stability and may be fabricated to a surface finish of 4 r.m.s. microinch.

Other ceramic parts for wear applications now being fabricated include bearings, pusher plates, guides and orifices. If you have a wear problem, particularly with localized abrasion or high skin temperatures, **contact CFI today.**

CFI *An Integrated Ceramics Service*

CFI Corporation
Department MD, Cottage Place
Mineola, New York—Pioneer 6-0371

Gentlemen: Please send me, without obligation, the following literature on CFI ceramics:

- ☐ "Custom Ceramic Parts for Industry" Brochure
- ☐ Microwave Ceramics Spec Sheet
- ☐ Have technical representative contact me.

Name_____

Title_____

Company_____

City_____ Zone____ State_____

For more information, circle No. 343

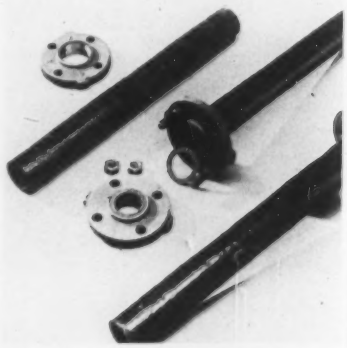
What's new IN MATERIALS

to 0.27 Btu/hr/sq ft/°F/in., reported to be somewhat better than that of phenolic foams, and about comparable to that of polystyrene foam.

Charring rate of the foams was determined by a modification of ASTM D757. Specimens were held against a cherry-red hot bar and the rate of char observed. No flame appeared during tests, and the material charred at rates ranging from 0.0830 ipm for 1.5 lb-per-cu-ft density specimens to 0.166 ipm min for 6.5 lb-per-cu-ft density specimens.

According to Doedens and Cordts, when the flame from a burner is applied to a specimen, the flame is extinguished immediately upon removal of the burner: the foam will not melt or drip when exposed to flame.

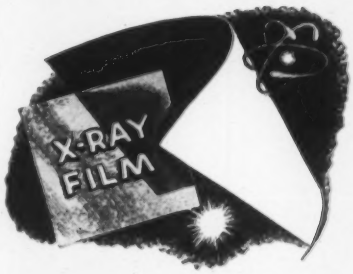
Foams made of chloromethyl ether resins are reported to be tough and nonfriable in densities of 1.5 to 3.0 lb per cu ft. The self-extinguishing foams are also said to be resistant to



Chemical resistant plastics pipe —Shown here are pieces of a new type of plastics pipe made of glass reinforced furane. The pipe, called Eonite, can carry hot corrosive liquids and gases at temperatures up to 300 F, and at pressures up to 150 psi without distorting or deteriorating. The producer, Cornelius A. Rauch & Asso., Inc., 1191 Sunset View Dr., Akron 13, Ohio, says the pipe can be sanitized easily by either steam or chemical sterilization, and is immune to fungus and bacterial attack. The furane resin, called Durez 16470, is a product of the Durez Plastics Div., Hooker Chemical Corp., North Tonawanda, N. Y.

KEY NO. 630

CREATIVE IMAGINATION *in Specialty* PAPERS*



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A leading manufacturer of x-ray film needed a wrapping paper that would be 1) opaque; 2) free of trace radioactivity commonly present in paper; and 3) of uniform thinness for ease of packing and dispensing film. Knowlton came up with a duplex paper – pure white on one side, pure black on the other – which consistently meets all three specifications.

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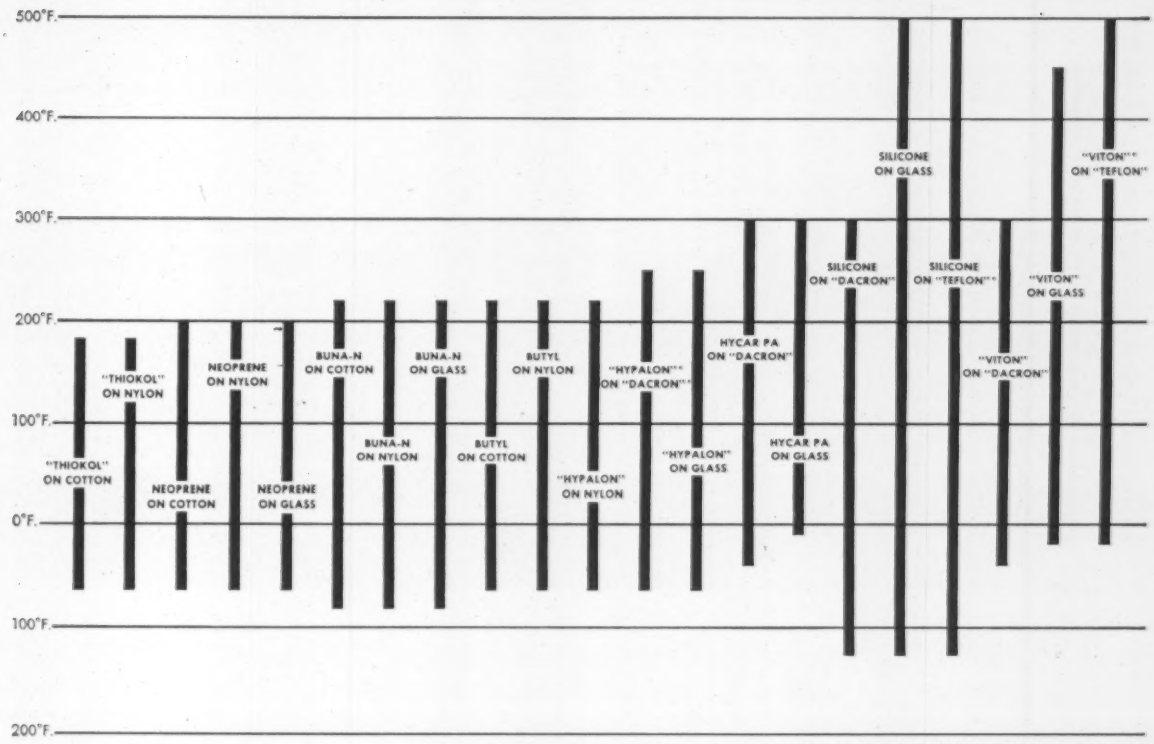

Upper serviceable limit is the highest temperature at which the material can be folded 180° back upon itself without cracking after 72 hours' exposure. Low limit is the lowest temperature at which the material can be bent around a 1" mandrel after 1 hour's exposure.

Temperature effects on the serviceability of Du Pont Fairprene®

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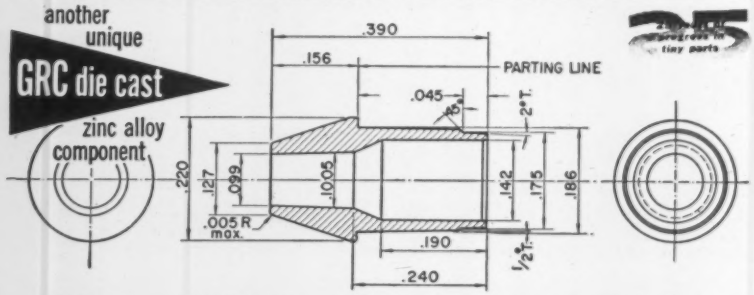
another unique **GRC die cast** zinc alloy component



GRC CUTS TINY BUSHING COST TO $2.00/M

D.e cast by GRC in zinc alloy in a single automatic operation, this former screw machine part for a ball point pen now costs little more than $2.00 per thousand in lots of a million. Each bushing is uniform, clean and accurate—no cut-off marks, no burrs, no secondary trimming and no scrap loss. Typical of the production economies and wide design latitude which GRC's exclusive patented methods have made possible on parts "no bigger than your thumbnail." (Maximum size is 1¼" long, ½ oz.; no size too small.)

Simple or complex, let GRC's unique techniques go to work for you . . . on tiny die cast and plastic molded parts made to order . . . on their wide variety of standard parts available in stock—die cast wing and round head thumb nuts and screws, cap nuts, molded nylon screws, gears and pinions—you'll be glad you did.

Write, wire, phone TODAY for samples, bulletins, spec sheets and prices. Send prints or specs for quotation

GRIES

GRIES REPRODUCER CORP.

World's Foremost Producer of Small Die Castings

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For more information, turn to Reader Service card, circle No. 385

What's new IN MATERIALS

alkalis and moisture.

The two researchers point out that to obtain the equivalent toughness in phenolic foams, densities higher than 5 lb per cu ft are required.

Reinforced foams

Combining the foams with inorganic fillers such as rock wool, glass wool or exploded mica produces: 1) increased strength (compressive strengths greater than 200 psi with 50% glass wool and 50% foam at densities of 5 to 6 lb per cu ft), 2) increased density, and 3) flame resistance equivalent to or better than that of unfilled foams.

Binders for inorganics

According to the two men, tough, self-extinguishing binder resins can be used with various types of inorganic reinforcing materials such as asbestos, glass wool, glass cloth and plaster aggregates to provide strong, heat resistant structural materials. Possible uses include refractory-type insulating components for high temperature applications.

Charring rates for the reinforced resin are said to range from a low of 0.082 ipm for bonded asbestos to 0.1592 ipm for bonded glass cloth. These charring rates were determined by the same method used for foams. They compare with a low of 0.2121 ipm for a self-extinguishing polyester-glass laminate to a high of 0.5 ipm for fiberboard. Phenolic-bonded glass wool charred at a rate of 0.25 ipm.

Other materials on the way?

Doedens and Cordts say that foams and binders are only a few of the many possible materials that can be derived from chloromethyl ether. They say properties of chloromethyl ether materials can be altered radically through use of additives and modifiers of various types.

Electron Beam Purifies Refractory Metals

A zone refining apparatus using electron beam bombardment to produce a floating molten zone in the specimen to be refined has been developed by MRC Manufacturing Corp., 47 Buena Vista Ave., Yonkers, N. Y. The specimen can be

Want low-cost parts finishing?

NOW—CHOOSE FROM 7 NEW ALMCO VIBRASHEEN MACHINES

TO DO YOUR

- DEBURRING
- DESCALING
- BURNISHING
- SURFACE REFINEMENT
- CLEANING

10 to 100 Times FASTER!

7 SIZES FOR EVERY JOB REQUIREMENT

Model	Tub Capacity	Tub Size, Inside		
		Length	Width	Height
VT-70	¾ gallon	7"	4¾"	6"
VT-71	1 cu. ft.	12"	12"	12"
VT-72	2½ cu. ft.	15"	16"	18½"
VT-75	5 cu. ft.	31"	17"	19½"
VT-77	7 cu. ft.	31"	17"	22½"
VT-712	12 cu. ft.	35"	25"	30⅜"
VT-717	17 cu. ft.	47"	25"	30⅜"

New VT-72 Vibrasheen being unloaded into optional hoist-pan. Note convenient height of controls.

ANOTHER REPORT FROM THE ALMCO ALBUM OF NEW PRODUCTS

IT'S A FACT! With the seven (7) new ALMCO Vibratory Machines, you can expect finishing time cycles 10 to 100 times faster than with standard horizontal barrel finishing equipment. It's a significant production break-through, made possible by creating constant vibratory motion to activate the entire mass of media and parts in the finishing container, as compared to only 20% activation with conventional barrel finishing methods.

The uniform vibratory motion of the media in recessed areas, blind holes and small I.D. dimensions make it possible to obtain optimum results on a multitude of applicable parts with intricate configurations that can not be completely processed in standard horizontal barrel machines.

What's more, this amazing metal finishing machine only requires 50% of the floor space that is taken up by any other machine of this type with a similar capacity. Time and motion is at the absolute minimum with all convenient operating conditions.

Tub features. Holds a 2½ cu. ft. load of parts and media. Equipped with vibrating mechanism adjustable for impact range of from 600 to 2550 lbs.; has a vibration frequency of 3380 rpm with variable drive optional. Pivots through 180° arc. Lined with tough ⅜" plastisol. Quick-acting cam-lock drain door facilitates flushing of tub.

Investigate today, the ALMCO *Vibra-Sheen way!*

FREE

NEWS ABOUT ALMCO'S NEW PRODUCTS

New Almco Album describes the latest in metal finishing machines, methods and media. Write today for free copy!

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IN ENGLAND: Almco Division of Great Britain, Ltd., Bury Mead Works, Hitchins, Herts, England

For more information, turn to Reader Service card, circle No. 524

why, oh why should a mold or die be made of Speer Graphite?

here's why

IT HOLDS ITS SHAPE.
Does not distort or change dimension regardless of temperature, repeated heating and cooling, or thermal shock.

•

IT WITHSTANDS HIGH PRESSURE.
Speer Graphite has compressive strength of approximately 7,000 psi.

•

IT BECOMES STRONGER WITH INCREASING TEMPERATURE.

•

IT IS CHEMICALLY INERT.

•

IT IS EASILY MACHINED
to close dimensional tolerances.

•

IT HAS HIGH THERMAL CONDUCTIVITY.

•

IT IS NOT WETTED BY MOLTEN METALS.

•

IT WILL NOT CRACK OR SPLIT.
Speer provides molds, dies and many other carbon or graphite parts for high-temperature applications, expertly machined to your own specifications. Call or write for further information.

SPEER Carbon Co.
CARBON PRODUCTS DIVISION
ST. MARYS, PENNSYLVANIA

For more information, circle No. 464

What's new IN MATERIALS

quickly heated to 6000 F, making the apparatus useful for the purification of refractory metals. Once the zone reaches the molten slate, the scanner moves on to the next adjacent area and continues to pass up and down the specimen as many times as required for purification. Impurities in the specimen rod are either vaporized into the chamber where high vacuum is maintained, or they are concentrated at both ends of the specimen and subsequently cut off.

High purity specimens produced by the apparatus are smooth, concentric single crystals free of bends and bumps. A specially designed filament control ensures this smoothness. KEY NO. 631

Glass Spray Coating Is Weather Resistant

A fiberglass spray coating that is said to give metals, wood and concrete a corrosion resistant surface is now available in limited quantities from Owens-Corning Fiberglas Corp., 717 5th Ave., New York 22.

Concurrently, a spray gun unit especially designed for applying the new coating has been developed by De Vilbiss Co., 300 Phillips Ave., Toledo 1, Ohio.

The coating is a homogeneous mixture of fiberglass flakes, resin, filler, accelerator and pigment (if desired).

Properties

Complete property data are not yet available, but accelerated weathering tests to date have shown virtually no deterioration of the coating.

Laboratory tests show that the coating has a shear strength of 800 psi and a dielectric strength of 500 v per mil.

Potential uses

The new coating is expected to be used on chemical and oil storage tanks, jackets for industrial smokestack insulation, and industrial ducting of chemical materials.

Other uses foreseen: a lining for railroad cars and trucks, an exterior coating for steel boats, a sealant from corrosive salts on highway

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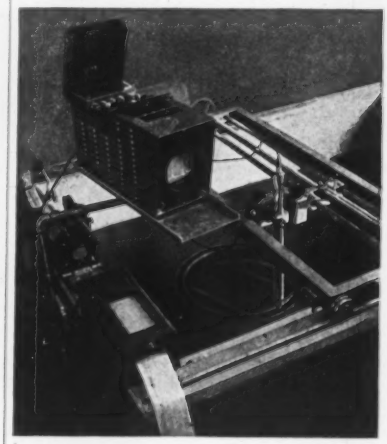
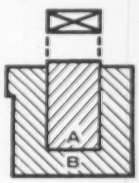
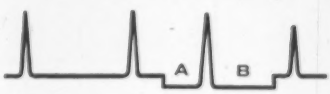


Early warning of internal defects prevents further waste of time and money on materials and parts that would later be rejected or fail in service / Here, for instance, a *Sonoray*® Ultrasonic Flaw Detector with accessory Model B *Sonogate* Flaw Alarm, immersion-scans a vital bi-metallic rotary seal. Every variation in bond between the two dissimilar materials is revealed on the CRT and strip-recorded as the part rotates on the submerged turntable / This is just one of the many DEW* techniques available with Branson Ultrasonic Flaw-Detection and Thickness-Gaging equipment. State your problem in detail when requesting further information.

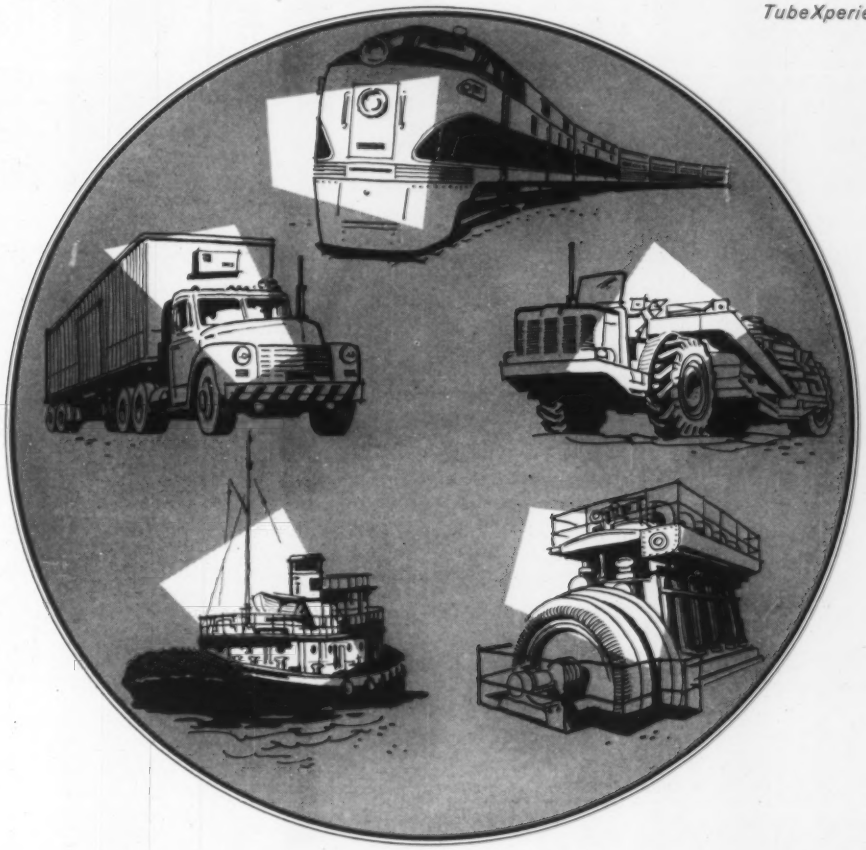




Since 1946 The Respected Name in Ultrasonics

Branson INSTRUMENTS, INC.
17 BROWN HOUSE RD., STAMFORD, CONN.

For more information, circle No. 488



Feedlines for hungry horsepower . . . diesel fuel injection tubing by Superior

Fuel injection systems are the heart of thousands of diesel-powered trucks, locomotives, roadbuilding equipment, electric generators, and marine power plants. The tubing that conveys the fuel from injection pump to nozzle assembly is an important component. It must resist the stresses of pressure and vibration, yet be ductile enough to be cold swaged and upset and be cold formed into loops and bends without excessive springback. It must have a clean ID, tremendous burst strength, and high fatigue resistance. Superior diesel fuel injection tubing is just such a premium product.

Type C-1008 and Type MT-1010 carbon steel tubing are most commonly specified for this application, but alloy and stainless steel tubing for pressures above 9000 psi and greater corrosion resistance is available. Superior also makes tubing for many other applications—supplies both general and special purpose tubing for aircraft, missiles, electrical, electronic, chemical, hydraulic, dairy and nuclear, to name a few. For complete information, write Superior Tube Company, 2006 Germantown Ave., Norristown, Pa.

SOME REASONS WHY SUPERIOR FUEL INJECTION TUBING IS A PREMIUM PRODUCT

- It will handle pressures to 9000 psi, is hydrostatically tested to various pressures according to specification
- It is cold drawn, dead soft annealed, and seamless
- It is ID conditioned to remove fissures and other defects
- It is free from ID radial cracks deeper than .005 in. or 5% of wall thickness, whichever is less
- It is annealed at finish in controlled atmosphere furnaces to produce a soft, ductile and scalefree material
- Fracture tests are performed when requested

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

All analyses .010 in. to ⅜ in. OD—certain analyses in light walls up to 2½ in. OD

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TRANSPARENT—COLORLESS

Consistently high quality . . . Clear . . . durable . . . economical. ¾" to 8½" O.D. 6 ft. and 20 ft. lengths, ¼" thickness.

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First choice of many of the nation's leading firms because it's easier to install, easier to inspect, won't corrode . . . speeds liquid flow.

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Busada Manufacturing Corporation

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For more information, turn to Reader Service card, circle No. 340

Designed with Wall Colmonoy Stainless Brazing . . . A Case History:

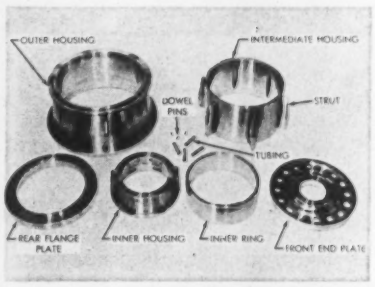
Brazing Speeds Building of Jet Engine Diffuser

The stringent design requirements of this diffuser assembly were met by stainless furnace brazing. The number of manufacturing operations were also reduced, cutting total cost.

The parts shown had to be joined for high performance service conditions. The Nicrobraz® stainless brazing filler metal used produced joints as strong as the parent metal.

Inaccessibility prevented machining after assembly, so allowable tolerance was only (plus or minus) .002". Precision application of brazing filler metal and of furnace temperatures kept distortion within the limits.

Call or write for more information about how our stainless brazing facilities can help you.



Wall Colmonoy Stainless Furnace Brazing Gave These Important Benefits:

- Brazed joints as strong as parent metal
- 13 parts joined in one brazing operation
- Distortion held to within ±0.002"
- No finish machining was needed
- Brazed assembly was fully annealed
- No clean-up, assembly was bright and clean

WALL COLMONOY CORPORATION

Stainless Processing Division

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Representatives in all key industrial areas

PROCESSING PLANTS: Detroit, Michigan • Morrisville, Pennsylvania • Dayton, Ohio • Montebello, California

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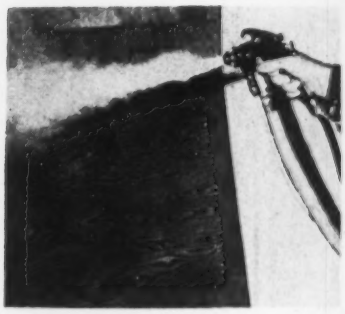
What's new IN MATERIALS



***Fiberglass coating** is first applied with new spray gun then . . .*

***. . . rolled** with a paint roller to give desired smoothness.*

bridge beams, and a water sealant for concrete block walls.

Protective coating is also decorative

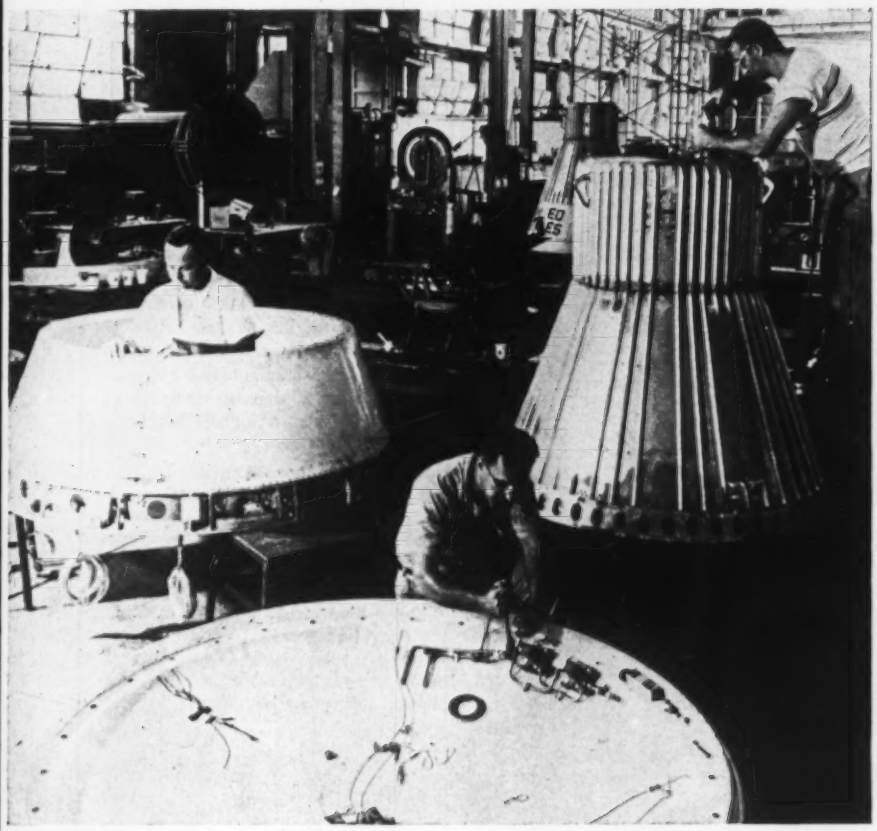
Owens-Corning says the new coating offers for the first time a combination of protection and decoration in a single coating since it is available with pigment if desired. The decorative aspect would be particularly desirable in such applications as swimming pools and masonry walls.

Glass flakes key to good properties

Fiberglass flakes are said to reinforce the coating by holding shrinkage to a minimum and increasing impact resistance. Crawling of the coating is impossible because of the high shear force that exists between the layers of flake and resin as applied, according to the developer.

The problem of pinholes found with some types of protective spray coatings is eliminated in the new

Product-Design
BRIEFS
from Durez



MORE ABOUT UNCLE'S MONKEY

Uncle Sam's first astronaut was a rhesus monkey, also named Sam, who took a 55-mile-high ride in a vehicle called Little Joe. It is Little Joe we're concerned with.

Specifically, with the part of Little Joe made from heat-resistant Hetron® polyester resin.

The full-scale Little Joe capsule is 9½ feet tall, 20 inches across the top and 6 feet across the rounded base. The bottom portion of this capsule consists of a heat-absorbing shield of glass-reinforced Hetron. Its several layers add up to an inch of thickness.

Hetron was chosen after intensive research because it provides an unusually high degree of inherent heat resistance, heat stability and fire resistance. All of these properties are important in coping with heat generated by atmospheric friction at escape velocity. Ease of fabrication was pretty important, too.

The large photo shows the two Hetron portions of the capsule: the bottom, in foreground; the heat-shield, at left.

Not only Uncle Sam's sophisticated scientists, but also the more prosaic industrial designers are interested in Hetron. It offers great promise in many different applications.

For example, it makes possible small boats that are fire-retardant. Because it is highly resistant to many acids, it finds wide use in scrubbers, ductwork and similar places where corrosive fumes quickly destroy other materials. It's being used for skylights on piers. One company even enclosed an entire building with it.

Hetron can by no means be considered a cheap substitute for other materials. Designers have been impressed with it and have used it simply because it performs its function better than any other material they might have used. Sometimes it costs less than other materials. Sometimes it costs more. But, in either case, it does things better, longer or more safely than anything else. We've got a data file on it if you're interested. Ask for Hetron File A.

For more information, circle No. 360

A THOUGHT FOR USERS OF DIE CASTINGS

When you put these seven parts together, you get a highly efficient low-cost pump for emptying drums of gasoline, lube oil or chemicals.

The manufacturer used to die cast these parts. Now he has them molded from a Durez phenolic. The switch to molding from die casting eliminated many finishing and assembly operations. Even the fine threads on one of the parts were flawlessly molded.

The switch to phenolic from aluminum added greater corrosion and chemical resistance. Being non-metallic, phenolics also prevent sparking and minimize the risk of handling volatile liquids.

For more facts about molding with versatile Durez materials, ask for Bulletin D400.

For more information on Durez products mentioned above, check here:

- ☐ Hetron polyester resins (File A)
- ☐ Phenolic molding compounds (illustrated Bulletin D400)

Check, clip and mail to us with your name, title, and company address.
(When requesting samples, please use business letterhead.)

DUREZ PLASTICS DIVISION

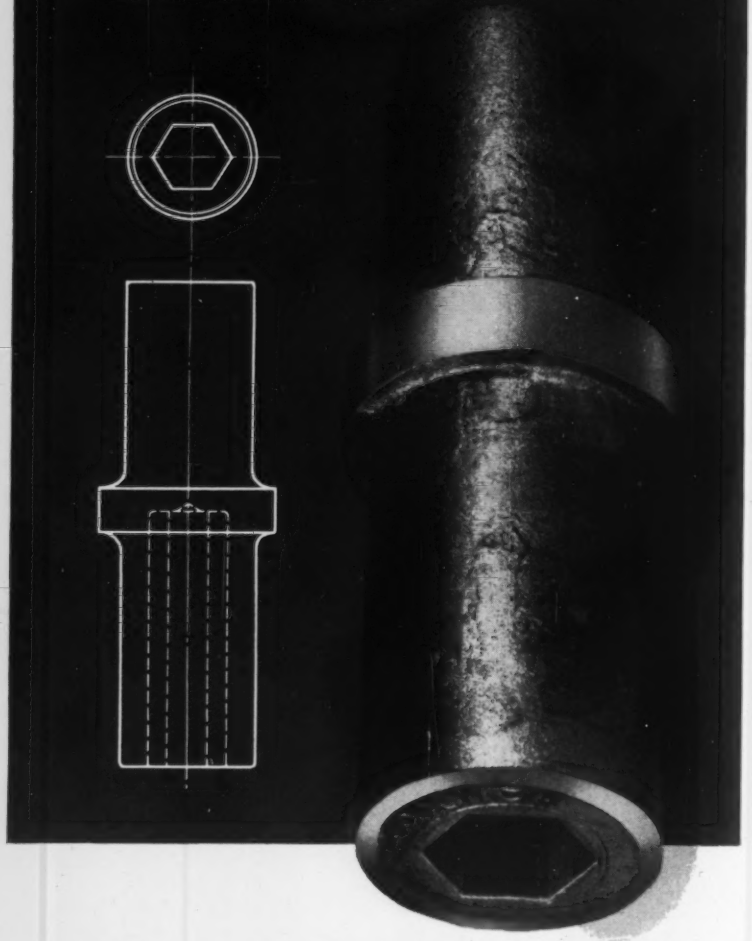
1409 WALCK ROAD, NORTH TONAWANDA, N. Y.

HOOKER CHEMICAL CORPORATION

HOOKER CHEMICALS PLASTICS

PROBLEM:

High breakage in rock drill chucks machined from steel bars.



SOLUTION:

AmForge developed a forged chuck with a pierced, hexagon hole. Tolerances in the hole were close enough to eliminate machining yet allow friction fit of the drill bits. $1.80 machining cost per chuck was saved. The need for a new machine tool was eliminated. This forged chuck reduced breakage, saved down time, cut production costs.

If you have a similar problem part, consult AmForge. Write for our new brochure or the name of your AmForge Sales Engineer.

Remember: *your problems...our challenge!*

AM FORGE DIVISION

a division of American Brake Shoe Company, 1220 West 119th Street, Chicago 43, Illinois. Two plants in Chicago, one in Azusa, California.

WHEN IT'S A VITAL PART, DESIGN IT TO BE FORGED

For more information, turn to Reader Service card, circle No. 538

product by isolating air bubbles or voids with many layers of flake glass. For example, a 20-mil thick coating of the product has 50 layers of fiberglass flake, roughly the equivalent of getting 50 coats of paint in one application.

According to the developer, sagging on vertical surfaces is eliminated by the shear force between the flakes. And surface haze is no problem because the flake reinforcement forms an air barrier without the addition of haze forming waxes. The flake reinforcement also reduces cure shrinkage, thereby improving the adhesive properties of the coating.

How coating is applied

The developer says satisfactory performance of the coating depends on proper preparation of the surface to be covered. Actual spraying of a surface is best accomplished at a distance of approximately 2 ft. The coating is then rolled with a paint roller to give desired smoothness and to orient the flakes, eliminating any possibility of pinholing.

KEY NO. 632

Epoxy Compounds for Tools, Patterns, Molds

Specially formulated epoxy compounds for making tools, molds and patterns are now commercially available from Allaco Products Co., 238 Main St., Cambridge 42, Mass.

Foundcast 101 is recommended for making molds and patterns. The compound is said to have good dimensional stability during room temperature cure, good machinability, and easy mold release.

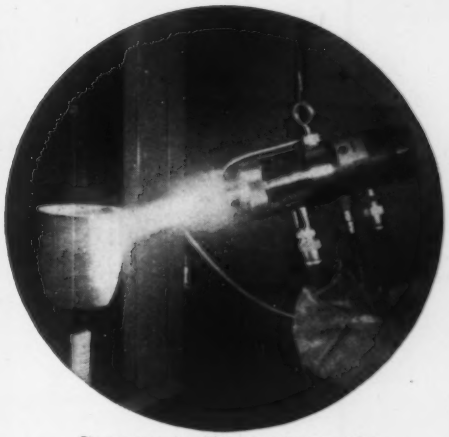
Sandbind 201 is used for making molds. The producer says molds made of the compound are sharp in detail and have greater durability than plaster molds.

Facecoat 301 is said to produce a smooth, hard epoxy coating on molds and patterns.

Multicast 401 is used for making epoxy jaws and chucks. It is said to have high tensile and impact strength, and good dimensional stability.

Layup 501 is used for making molds and patterns with fiberglass

NOW—15,000°F. PLASMA FLAME SPRAY IN YOUR OWN PLANT



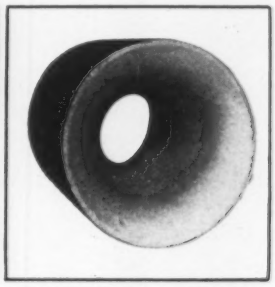
Flame spraying hi-temperature crucible

Apply coatings of high melting point materials such as tungsten, tungsten carbide, molybdenum, chromium carbide, titanium oxides, calcium zirconate, rare earth oxides. Operates at 10,000°—15,000°F.

Now any material that can be melted without decomposing can be sprayed. Despite high melting temperature, object sprayed stays cool.

High fluidity of particles and high velocity of impingement bond particles together to produce high density coatings semi-fused to work surfaces. Absence of air eliminates oxidation.

Spraying tungsten on brass mandrel



Tungsten coated graphite part

Metco Type MB Plasma Flame Spray Gun

Here is a valuable new tool for the metalworking research department or production line. The METCO Plasma Flame Spray Gun operates on inexpensive inert gases, with high electrical power conversion efficiency and long component life. Continuous hot gas streams, as high as 30,000°F., with accurate control of temperature, can be generated for costs of ⅓ to ½ those of oxygen-fuel gas equipment for equivalent heat output.

Other advantages include push-button operation, extremely simple training of personnel, elimination of flash-back and explosion problems.

Materials that can be sprayed

Specifically, a wide range of metals and their oxides, carbides, borides, and refractories have been sprayed with the standard apparatus on various shaped objects and mandrels. Coating densities are easily controlled and up to 98% of theoretical can be obtained. Lowered oxide contents, with improved bond and tensile strengths are additional advantages.

Plasma Flame — how it works

The METCO Plasma Flame Spray Gun produces an arc contained in a water-cooled nozzle. An inert gas, blown through and around the arc, is "excited" to energy states having temperatures approaching 30,000°F. This Plasma "Flame" is used for melting and spraying any desired material.

The METCO Plasma Flame Gun is the latest development in flame-spraying equipment by METCO. Write today for free bulletins describing the various flame spraying processes and the Plasma Flame Spray Gun.

METCO INC.

FORMERLY METALLIZING ENGINEERING CO., INC.

Flame Spray Equipment and Supplies

1175 Prospect Ave., Westbury, Long Island, N.Y.

Telephone: Edgewood 4-1300 Cable: METCO

In Great Britain: METALLIZING EQUIPMENT CO. ,Ltd. Chobham-near-Woking, England

Please send me free bulletin on the Metco Plasma Flame Spray Gun.

Name _____ Title _____

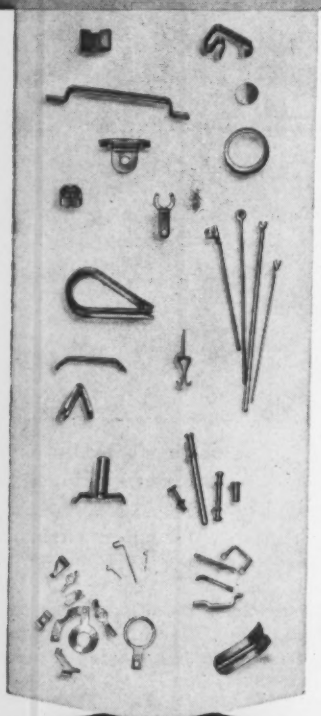
Company _____

Address _____

City _____ Zone _____ State _____

For more information, turn to Reader Service card, circle No. 394

PRECISION WIRE FORMS



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Art Wire specializes in wire forms designed for today's automatic production lines . . . manufactured with the precision and uniformity that assure the economy of an uninterrupted work flow. Reduced down-time, and the lower costs made possible by Art Wire's modern production methods mean greater savings to you, and greater profit in your operations.

ART WIRE AND STAMPING CO.
13 Boyden Place, Newark 2, N. J.

For more information, circle No. 333

What's new IN MATERIALS

reinforcement. Molds and patterns made of the compound do not delaminate, have a hard surface and are dimensionally stable.

KEY NO. 633

Urethane-Coated Wire Is Soldered Quickly

Fast solderability is the chief characteristic of magnet wire coated with a new urethane enamel. For example, soldering time at 685 F for No. 29 AWG wire coated with the new enamel is 2 sec, compared to 4 sec for conventional wire enamels.

The new material, designated Carthane 8063, is marketed by Carwin Co., Polymer Products Div., North Haven, Conn.

The enamel, which is designed for dip application, is said to have a higher solids content for the same viscosity than any urethane enamel previously produced. It can be applied to magnet wire at a solids content of 33%.

According to Carwin, the enamel is exceptionally resistant to solvents, including acetone, in both single and heavy coats. It is also said to pass standard tests for adherence, flexibility, abrasion and aging.

KEY NO. 634

Sheet Adhesive Joins Honeycomb Structures

Metlbond 406 is the name given to a large-area, low pressure adhesive system designed for joining honeycomb structures. A big advantage of the new adhesive is that it can be used for joining honeycomb cores to each other and to the sandwich skin. Previously, a special adhesive was required for joining cores to sandwich skin.

The adhesive system is available from Narmco Resins and Coatings Co., Div. of Narmco Industries, Inc., 600 Victoria St., Costa Mesa, Calif. It consists of a translucent, calendered sheet, a liquid primer, and a heavy paste for tacking the sheet to adherends before curing.

The new adhesive cures at 350 F without releasing solvents or con-

Wiley BOOKS

PROPERTIES AND STRUCTURE OF POLYMERS

Elucidated by Stress Relaxation Studies, *By* ARTHUR V. TOBOLSKY, *Princeton University*. Explains the important features of the mechanical behavior of polymers in terms of fundamental principles of molecular structure and behavior. This book reduces the seemingly complex physical properties of polymers to easily understood generalizations. It also shows how the study of mechanical behavior of polymers can be used to solve problems in polymer chemistry often unsolvable by other methods. *1960. 331 pages. $14.50*

THERMOELECTRICITY

Edited by PAUL H. EGLI, *U. S. Naval Research Laboratory*. This book is divided into four sections: a broad survey of the basic concepts of thermoelectricity; an examination of the physics of thermoelectric performance; discussions of the more important problems that arise in thermoelectricity research; and an exploration of the relative merits of static and transient methods of measuring thermal conductivity. A conclusion written by Dr. Egli synthesizes the ideas in the main body of the book. *1960. 416 pages. $10.00*

DYNAMIC BEHAVIOR OF THERMOELECTRIC DEVICES

By PAUL E. GRAY, *M.I.T.* The first published report to investigate the small-signal dynamic behavior of thermoelectric heat pumps and generators. This approach permits analysis of linear models describing the behavior of these devices. These analyses produce a number of small-signal transfer-functions that can be used to compute the response of devices in either the frequency-domain or time-domain. *A Technology Press Research Monograph, M.I.T. 1960. 136 pages. $3.50*

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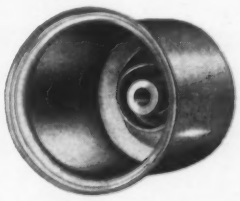
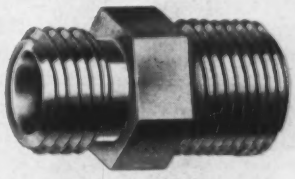
Because the diversified facilities of his company encompass a wide range of manufacturing methods, the Man From Mueller Brass Co. is in the unique position of being able to offer you an intelligent, unbiased analysis and recommendation of the one best method of producing your particular part. When you are designing, specifying and purchasing fabricated parts . . . call in the Man From Mueller Brass Co. You will get the best product at the best price . . . made the *one best way!*

FORGINGS

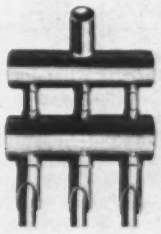


COLD-PREST® IMPACT EXTRUSIONS

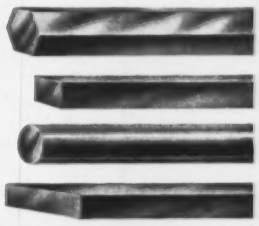


SCREW MACHINE PRODUCTS

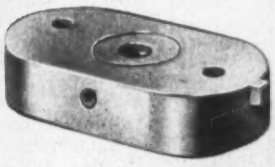
SAND CASTINGS



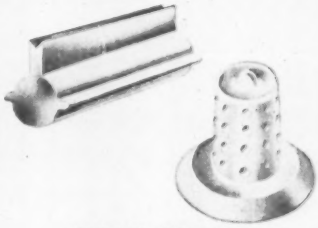
FORMED COPPER TUBE



SPECIAL ALLOY ROD FOR FORGINGS AND SCREW MACHINE PRODUCTS



SINTEEL® POWDERED METAL PRODUCTS



CUSTOM EXTRUDED PLASTIC SHAPES AND INJECTION MOLDINGS

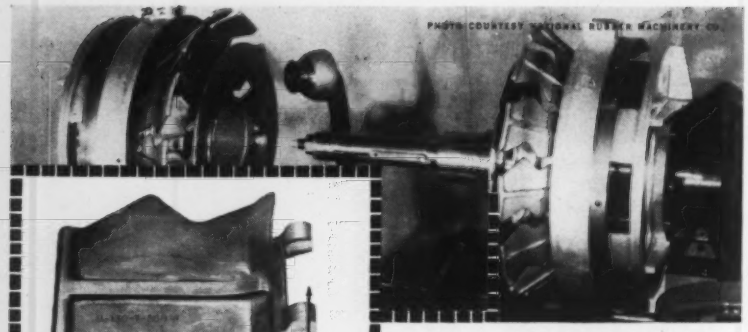
MUELLER BRASS CO

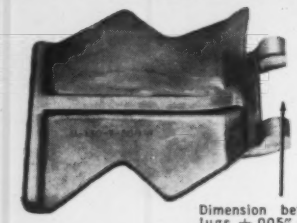
MUELLER BRASS CO.

PORT HURON 21, MICHIGAN

287-R

For more information, turn to Reader Service card, circle No. 419





OPC CLOSE TOLERANCE CASTINGS ELIMINATE MACHINING TIME

The 24 plydown fingers on NRM's Models 58 and 60RS Tire Building Machines are aluminum alloy castings, ASTM-C4A-T4 Temper. Meeting extremely close tolerance requirements, and boasting a 100 micron finish, these OPC castings eliminate all the machining time formerly required when sand castings were used. And NRM can drill a 3/16" hole through both lugs in one operation — that's precision casting, by OPC, that saves time and money on small parts production. Your small parts, 10 or 10,000, can be OPC-produced in less time, at lower cost. Your sketch or print is all you need send for a prompt quotation.

OPC

PLASTER MOLD CASTINGS — Brass, Bronze, Aluminum, Beryllium Copper

OHIO PRECISION CASTINGS, INC.

109 Webb St. Dayton 3, Ohio

WRITE FOR CATALOG

For more information, turn to Reader Service card, circle No. 429

custom molders of **FIBERGLASS** reinforced polyester

Your product, in whole or in part, may be ideally suited for adaption to an incredibly strong, amazingly lightweight, beautifully textured Lewis one piece molding.

Let our experienced plastic engineering staff study your product, whether it be in existence, or still in blueprint form.

√ MOLDED-IN COLORS √ WON'T ROT OR RUST √ LIGHTER THAN ALUMINUM

√ STRENGTH LIKE STEEL √ CHEMICAL RESISTANT √ SOUND DEADENING

Fiberglass reinforced plastics stimulate fresh, modern style appeal... and are exciting new sales potentials to a wide variety of consumer and industrial products. And no wonder, for the outstanding physical characteristics of this basic new material, plus its many profitable production advantages, create great interest and impact everywhere. Dimensional stability... chemical resistance... tolerance to temperature extremes... rust-proof, rot-proof, corrosion-proof... and a limitless variety of lasting colors molded-in for life... all these benefits, and many more, are to be found with Lewis reinforced polyester moldings.

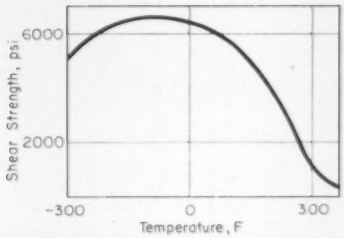
More and more leading manufacturers are depending on Lewis for quality reinforced plastic moldings. Our trained engineers are ready to assist you in converting your product to this new material.

G. B. LEWIS COMPANY

DEPARTMENT M/DE • WATERTOWN, WISCONSIN

For more information, turn to Reader Service card, circle No. 498

What's new IN MATERIALS



***Shear strength** of Metlbond 406 adhesive at various temperatures.*

densation products. It flows just before cure, resulting in a filleting action that provides a strong sandwich construction at a lower adhesive weight than heretofore possible, according to Narmco. Metal-to-metal bond strengths are said to be exceptionally high. (For information on joining honeycomb structures, see M/DE, Apr '60, p 123.)

KEY NO. 635

Other News . . .

Metals

▸ Structural steel panels for a variety of decorative applications are now available from John J. Fannon Products Co., 3000 E. Woodbridge Ave., Detroit 7. The panels, called Metalcel, contain hexagonal cells.

KEY NO. 636

▸ Joseph T. Ryerson & Sons, Inc., Box 8000-A, Chicago 80, is marketing a new aluminum alloy building sheet developed by Reynolds Metals Co. that is designed for use in cabinets, display racks, fan blades, electrical cover boxes and kick plates. The aluminum sheet is said to cost 4 to 11¢ per lb less than other non-heat treatable aluminum alloy sheets.

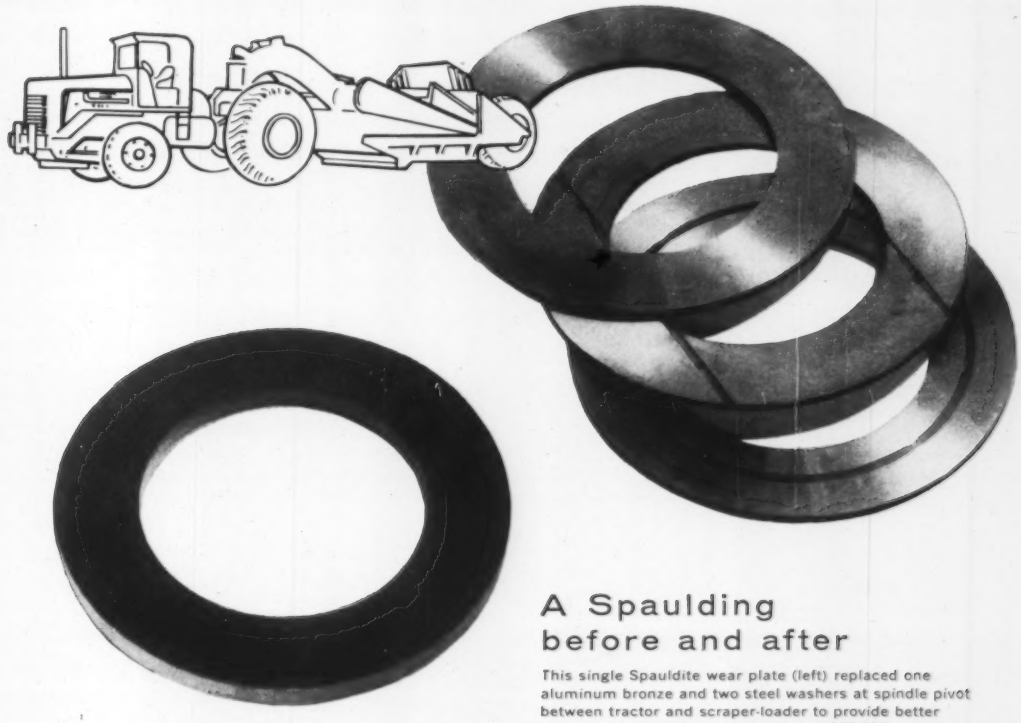
KEY NO. 637

▸ Indium spheres with purities held to 99.9995% are now available from Accurate Specialties Co., Inc., 37-11 57th St., Woodside 77, N. Y. The spheres are used in forming alloy junctions in germanium transistors and diodes.

KEY NO. 638

Plastics

▸ Extruded sheets of Penton chlorinated polyether measuring 0.040 in. thick by 21 in. wide are now available from U. S. Gasket Co., Plastics



A Spaulding before and after

This single Spauldite wear plate (left) replaced one aluminum bronze and two steel washers at spindle pivot between tractor and scraper-loader to provide better wear under shock loads estimated at 120,000 pounds, eliminate need for lubrication, reduce cost by 40%.

NOW IT'S CALLED VALUE ANALYSIS

As any Spaulding customer can tell you, the only thing new about Value Analysis is the name.

Spaulding has been rendering this service for years with engineers who evaluate a part or assembly, then show how it can be made better, easier and at a lower cost with a Spaulding Material, processed by Spaulding's own Fabricating Department.

The unique characteristics of Spaulding Industrial Plastics and Vulcanized Fibre hold the same advantages for *your* product.

SPAULDING FIBRE COMPANY, INC.

372 Wheeler Street, Tonawanda, New York

free **Value Analysis Brochure**

Send for your copy now.

SPAULDING FIBRE COMPANY, INC.
372 Wheeler Street
Tonawanda, New York

Please send a free copy of the brochure, "Spaulding Value Analysis."

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For more information, turn to Reader Service card, circle No. 463

No. 17 of a series

Eastman 910 Adhesive solves another production bottleneck

Hill, Brown Fabrics Company, of Clifton, New Jersey, operate approximately 100 Jacquard weaving looms.

Once started, a loom operates round-the-clock until the weaving run is completed. Occasionally, however, a tooth on the cast iron comb-like Griff Rack breaks. In order to repair the rack by brazing it must be removed from the loom, causing shipments to be delayed by as much as a day.

Company engineers find they can now effect a temporary repair within minutes without removing the rack from the loom by using quick-setting, high-strength Eastman 910 Adhesive and thus complete the run on schedule.

Eastman 910 Adhesive is making possible more rapid repairs; faster, more economical assembly-line operations and new design approaches. It is ideal where extreme speed of setting is important, or where design requirements involve joining small surfaces, complex mechanical fasteners or heat-sensitive elements.

Eastman 910 Adhesive is used as it comes. No mixing, no heating. Simply spread the adhesive into a thin film between two surfaces. Light manual pressure triggers setting. With most materials, strong bonds are made within minutes.

What production or design problem can this unique adhesive solve for you?

Bonds Almost Instantly with Contact Pressure
No Heat...
No Catalyst...

For a trial quantity (⅓-oz.) send five dollars to Armstrong Cork Co., Industrial Adhesives Div., 9109 Dunbar Street, Lancaster, Pa., or to Eastman Chemical Products, Inc., Chemicals Div., Dept. E-9, Kingsport, Tenn. (Not for drug use)
See Sweet's 1960 Prod. Des. File, 7/E

For more information, circle No. 362

What's new IN MATERIALS

Div., Garlock Inc., 602 N. 10th St., Camden 1, N. J. The sheets are recommended for use in lining vessels and other equipment containing corrosive liquids. **KEY NO. 639**

▸ Color-coded TFE pressure sensitive tapes are being marketed by Connecticut Hard Rubber Co., 407 East St., New Haven 9, Conn. under the trade name Temp-R-Tape. The colored tapes are supplied in 18-yd rolls, in widths from ¼ to 2 in. **KEY NO. 640**

▸ High density polyethylene has been added to the line of plastics marketed by Eastman Chemical Products, Inc., 260 Madison Ave., New York 16. The material will be sold under the trade name Tenite. **KEY NO. 641**

Rubber

▸ A new Viton rubber compound that can be bonded to metal or molded into o-rings, gaskets and other shapes has been introduced by Stillman Rubber Co., 5811 Marilyn Ave., Culver City, Calif. Gaskets and o-rings made of the compound, called SR-278-90, are said to provide positive sealing against solvents, lubricants, fuels and acids over the temperature range –65 to 600 F. **KEY NO. 642**

▸ Minnesota Rubber Co., 3630 Wooddale Ave., Minneapolis 16, Minn. is supplying a new silicone rubber tubing for use as an electrical insulation. Called Sil-Blu, the tubing is sold in sizes ranging from ⅛ in. i.d. with 1/16 in. wall thickness to ¾ in. i.d. with ¼ in. wall thickness. **KEY NO. 643**

Other nonmetallics

▸ Two new ferromagnetic materials are said to complete a series of magnesium-manganese-aluminum ferrites designed for use in microwave devices. The two materials, called M-092 and M-112, are available from Motorola Inc., Solid State Electronics Dept., 8201 E. McDowell Rd., Scottsdale, Ariz. **KEY NO. 644**

▸ Ceramics for Industry Corp., Cottage Pl., Mineola, N. Y. has introduced a new series of microwave absorber ceramics called No. 1000. The ceramics are used in mode suppressor and variable attenuator applications. **KEY NO. 645**

▸ A new aluminum oxide abrasive, developed especially for stainless

STRAITS TIN REPORT

MALAYAN TIN BUREAU

News of developments in the production and uses of tin

Nontoxic, inert, malleable — all three are descriptive of tin. One of man's oldest metals, it is still vital in our modern economy. For example —

For product protection, 60.7% of all tin consumed in the U.S. is used in manufacturing tinplate, largely for containers. 135 industries package a total of over 2500 products in more than 42 billion cans annually!

For joining and sealing, 14.8% of all tin used is in alloy with lead to form solder.

For strength and corrosion resistance, 6.5% is consumed in the tin-copper alloy, bronze.

For anti-friction properties, 4.1% is consumed in the high-tin/lead alloy, babbitt, generic for bearing metals.

For protective coatings, tinning accounts for 3.9%. Hot-dipped tin provides a smooth, reflecting surface, particularly adaptable for food processing equipment.

For castability, white metal — alloys of tin, antimony, lead, bismuth, and copper — account for 3.2% of U.S. tin consumption.

Miscellaneous alloys use 4.2%; chemicals, 1.1%; and collapsible tubes, 1.5%.

There's no substitute for tin . . . and no substitute for Straits Tin from Malaya — recognized standard for quality and uniformity, available in reliable supply from sizeable reserves.

Write today for more data on these items or for a free subscription to TIN NEWS—a monthly bulletin on tin supply, prices and new uses.

The Malayan Tin Bureau
Dept. 24J, 2000 K Street, N.W., Washington 6, D.C.

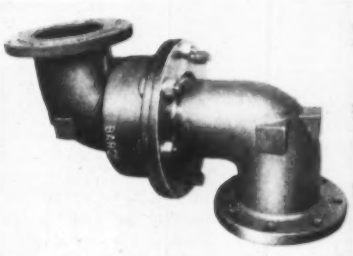
For more information, circle No. 409

3M COMPANY CHEMICALS THE RAW MATERIALS OF PROGRESS

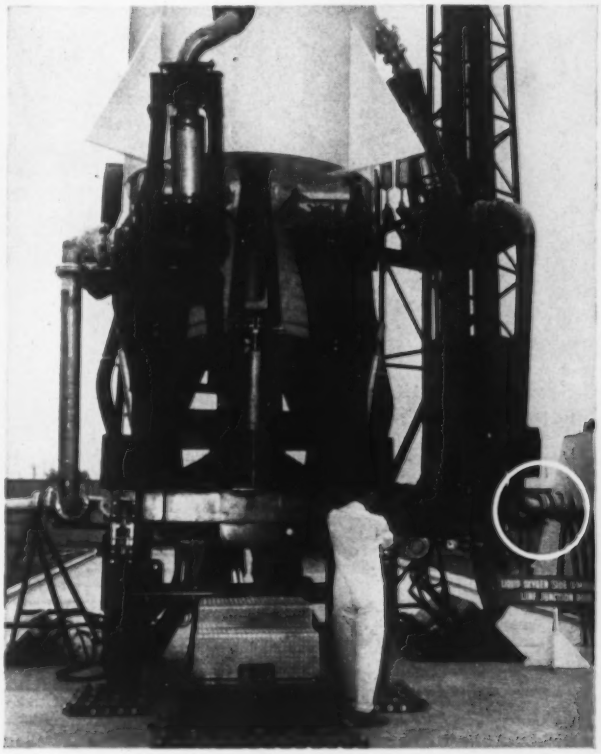
Liners of KEL-F® BRAND PLASTIC for ball joints... FUEL-PROOF and WEAR-RESISTANT

Flexible ball joints (see photo below) manufactured by the Barco Manufacturing Company of Barrington, Illinois, provide for swiveling or angular flexing and thermal contraction in fueling lines for today's rocket powered ballistic missiles. Like the pipeline, these joints must withstand the corrosive action of such highly volatile fuels as LOX and JP fuels 3, 4 and 5. A sealing and lining agent was required that would make the joints impervious to the corrosive action of these fuels.

Barco Manufacturing Company found the answer. KEL-F Brand Plastic was supplied to them in sheet form. Barco, in turn, die-cut the KEL-F plastic into the required shapes for use as liners and sealers in the swivel mechanism of the ball joints.



Why KEL-F Plastic? Because the corrosive action of high energy rocket fuels can't faze it. Because cold can't shatter it . . . heat can't melt it. It's performance proved. KEL-F Plastic withstands a temperature range of −320° F. to +425° F. In addition, its excellent flexibility and high impact and compressive strength provide an extra safety measure to the joints to insure against dangerous blow-outs and costly leakage.



KEL-F Plastic is ideally suited for many uses in the field of rockets, missiles and aircraft because it is chemically inert, thermally stable, has high impact, tensile and compressive strength plus zero moisture absorption and easy moldability. Among its many uses: O-rings, LOX lip seals, valve diaphragms, flow meters and fuel bladders.

For complete performance characteristics, write today specifying area of interest to: 3M Chemical Division, Dept. KAR-90, St. Paul 6, Minnesota.

"KEL-F" is a Reg. T. M. of 3M Co.

CHEMICAL DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

. . . WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

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MOSINEE MAKES MAGIC WITH PAPER

Laminating and Coating Papers

- Developed to your requirements for performance under conditions of moisture, mold, fire, low temperatures, etc.
- Ideal for laminating with foil, glassines, films, etc. . . . for coating with waxes, plastics, resins, organosols, plastisols.
- Uniformly hard, sound rolls without soft spots or corrugations. Free from shives, other imperfections.
- Basis weight and caliper across the sheet plus other specific characteristics will be uniform from roll to roll . . . from carload to carload.

MOSINEE
PAPER MILLS COMPANY
MOSINEE, WISCONSIN

FREE—DATA FILE AND PAPER TERMS DICTIONARY
Write Dept. MD-9

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What's new IN MATERIALS

steel billet and slab grinding, has been introduced by Norton Co., Worcester 6, Mass. The abrasive is known as 75 Alundum. Norton says tests show it is capable of removing twice as much metal per wheel as the best grinding wheels previously used. KEY NO. 646

Finishes

▸ Two new silicone rubber coatings have been announced by Melpar, Inc., 3000 Arlington Blvd., Falls Church, Va. Melcoat S-100 is suitable for cushioning fragile parts against shrinkage during encapsulation. Melcoat S-200 is suitable for use as a thermal insulation. KEY NO. 647

▸ An improved phosphate cleaner is said to remove rust, corrosion and scale from ferrous and nonferrous metal surfaces in one operation. The product, designated Chem-Bond and developed by Bell-Ray Chemical Corp., 121 N. Broadway, Milwaukee 2, Wis., is easy to rinse off. KEY NO. 648

▸ A new series of coatings are said to permit color coding of metal parts subjected to temperatures from 600 to 1700 F. The coatings are called Het-Rem H-170 and are available from Speco, Inc., 7308 Associate Ave., Cleveland 9. Typical applications include heat transmission lines, stacks, vents, ovens, engine heads and mufflers. KEY NO. 649

Adhesives

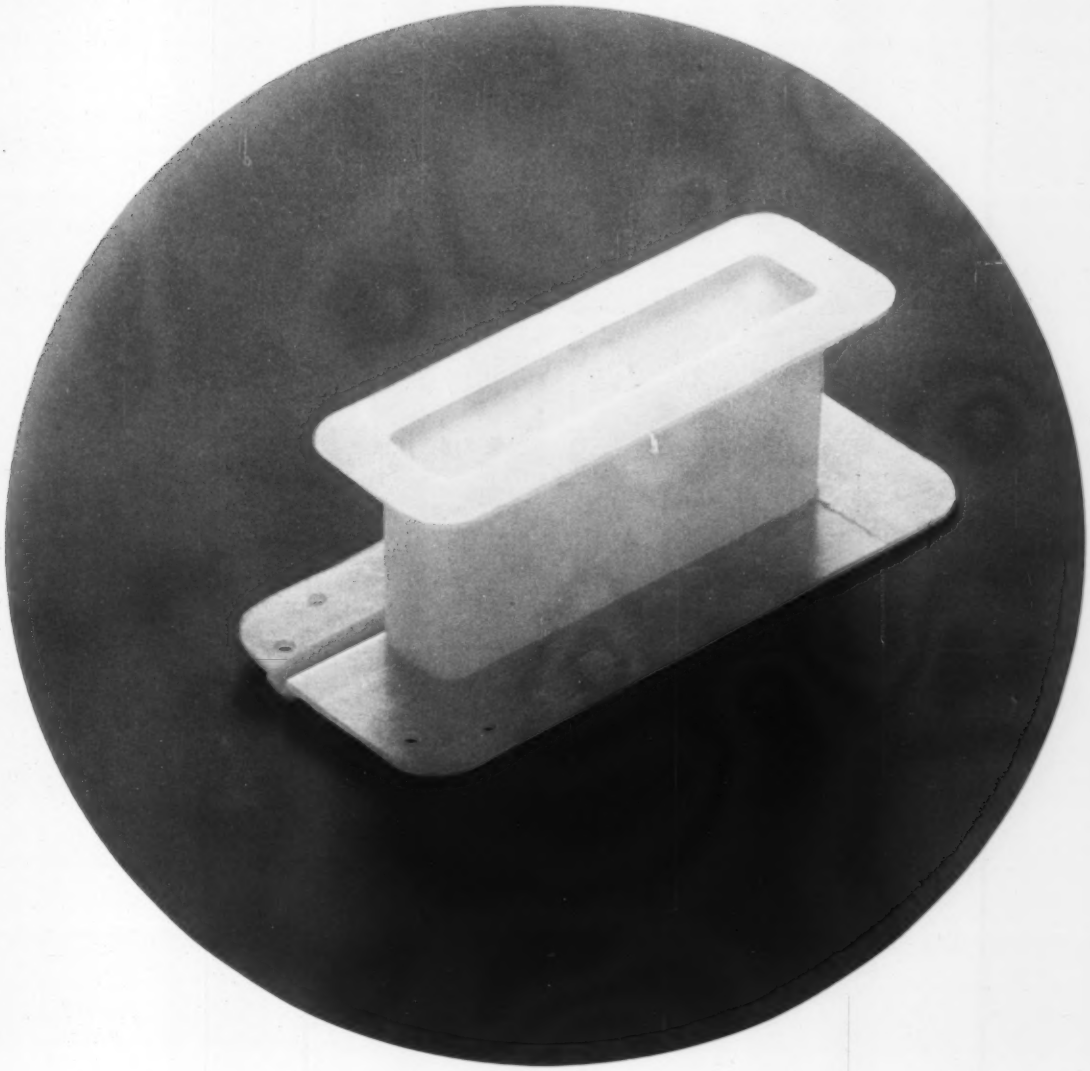
▸ An oil resistant synthetic rubber-base adhesive for joining wood, felt, cork, fabrics, leather and other materials to themselves and to metals has been announced by Schwartz Chemical Co., Inc., 50-01 2nd St., Long Island City 1, N. Y. The product is called Rez-N-Glue No. 244. KEY NO. 650

▸ Wilhold Glues, Inc., 2943 W. Carroll Ave., Chicago 12, is marketing an epoxy-metal adhesive for bonding metals, wood and glass to themselves and to other materials. The new material can also be used for repairing metal and nonmetallic products. KEY NO. 651

▸ A two-part, 100% solids epoxy adhesive has been designed for bonding nylon to nylon at room temperature. The adhesive, developed by Hysol Corp., Olean, N. Y. and called Hysol 4219, is not affected by immersion in JP-4 fuel, alcohol or naphtha. KEY NO. 652

For more information, circle No. 323 ➤

Plaskon NYLON 6, GLASS-FILLED, TAKES HEAT, STRESS



Bobbins like this, of Plaskon Nylon 6 reinforced with glass fiber, contribute to a better exciter generator, according to Electric Machinery Mfg. Co., Minneapolis, Minn. . . . "The molded bobbins provide a durable and economical means of providing the field winding in one unit for insertion on the pole." Glass fiber reinforced Nylon 6 provides better dimensional stability and rigidity plus good thermal stability, important to trouble-free operation.

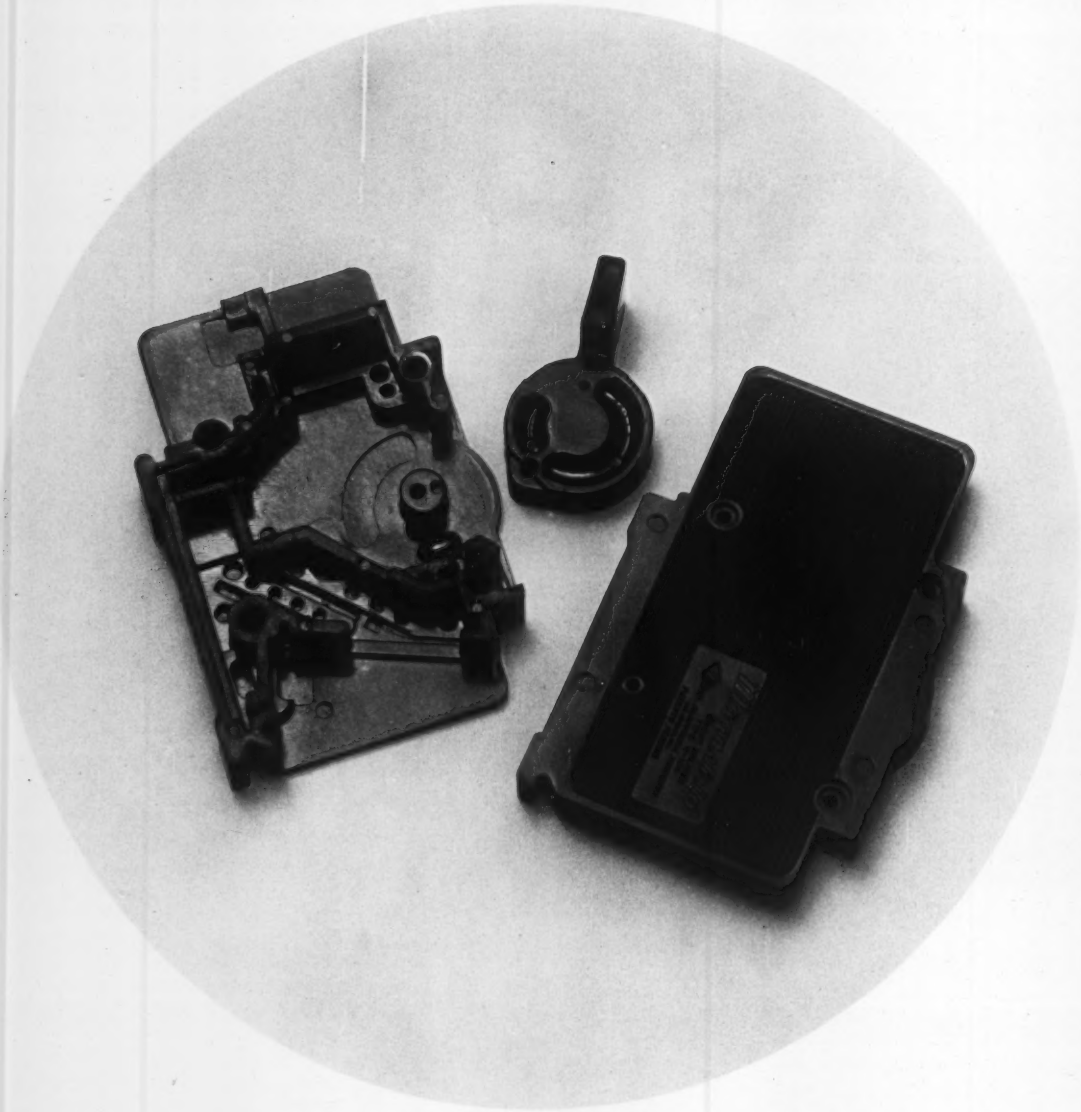
The molding compound used in the bobbin, Nylafil G3, consists of Plaskon Nylon formulated with glass filler in a rigidly controlled process by Fiberfil, Inc., Warsaw, Ind. Plaskon Nylon 6 offers toughness, light weight, resistance to abrasion, corrosion and heat, lower shrinkage, greater impact strength and easier colorability. It molds at lower temperatures, easing the problems of thin-section molding and providing better dimensional stability. Several varieties of Plaskon Nylon 6 are available for extruded products . . . and their extrudability is good.

Write us for more information about hard-working Plaskon Nylon — or Nylafil G3.

PLASTICS AND COAL CHEMICALS DIVISION
40 Rector Street, New York 6, N. Y.

Allied Chemical

Plaskon WOOD-FLOUR FILLED UREA...EFFICIENT



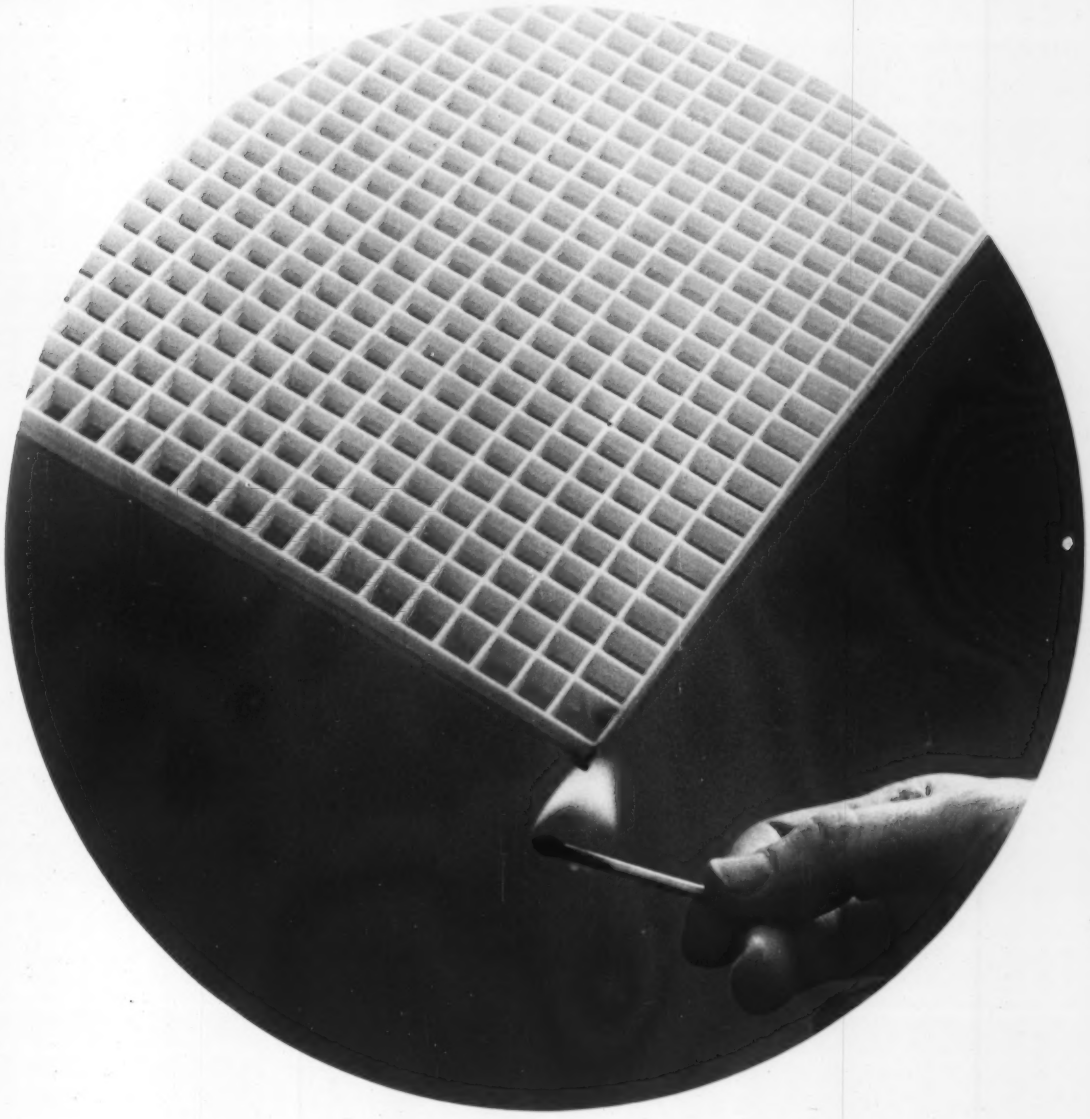
Efficient both electrically and economically, this Plaskon Wood-Flour Filled Urea circuit breaker case delivers superior arc resistance . . . 80-100 seconds (ASTM). The maker states that its dielectric and insulating properties have proven satisfactory in this circuit breaker case, as well as other cases in his line.

Allied Chemical Corporation developed this material specifically for high-speed automatic molding of electrical parts; Plaskon Wood-Flour Filled Urea is now thoroughly proven in the field. It matches or exceeds the more expensive alpha-cellulose urea in all properties except translucency and color range. Available in NEMA brown or standard black.

Other important properties of Plaskon Wood-Flour Filled Urea: Superior color-fastness • Impervious to household solvents • Non-electrostatic surface.

You may well profit by switching to Plaskon Wood-Filled Urea . . . write us for more information and for samples.

Plaskon FIRE-RESISTANT UREA . . . NON-STATIC, TOO



Lighting grids like this made of Plaskon Fire-Resistant Urea UFR-28 stand up well to flame!

Where the UL fire tunnel test may cause other white and pastel materials to blister, drip or contribute readily to flame spread, this grid has a low UL flame spread rating of 25 . . . considered "Non-Combustible" in general practice! In addition, its ASTM rating is "Non-Burning."

Called "N. C. Gratelite" by maker Edwin F. Guth Co., St. Louis 3, Mo., this new grid eliminates static electricity charges, too . . . doesn't attract dust.

Other important properties of Plaskon Fire-Resistant Urea UFR-28 . . . high dielectric strength; rigid enough to support itself; hard surface resists scratching and abrasion and facilitates cleanup; colors are spectro-photometrically controlled for precise lighting values.

Look to Allied for Urea Molding Compounds when you need good fire resistant and electrical properties, rigidity, strength, wide color range, or combinations of these. Plaskon materials and know-how to help solve your problems are freely available. We'd like to hear from you.

PLASTICS AND COAL CHEMICALS DIVISION
40 Rector Street, New York 6, N. Y.

Allied Chemical

Plaskon ALKYDS PROVIDE HIGHEST ARC RESISTANCE

The base of this rectifier tube is made of Plaskon Alkyd Molding Compound. The tube's maker, Chatham Electronics, Division of Tung Sol Electric, Inc., states that . . .

1. Plaskon Alkyds provide high arc and insulation resistance. A three kilovolt potential between base pins presented no problem.
2. The high mechanical shock resistance of Plaskon Alkyd helps this tube to withstand 900 G's, as required by military specification.
3. In this application, a maximum bulb temperature of 250 C (482 F) has no adverse effect on the Plaskon Alkyd base.
4. The fast cure rate, dimensional stability and uniformity of Plaskon Alkyd permit high-speed, high-precision parts production.

Plaskon Alkyd Molding Compounds are available in three forms . . . free-flowing granular for high-speed automatic molding; glass-reinforced impact grades combining excellent mechanical and electrical properties; putty types for encapsulation. For more about Plaskon Alkyd Molding Compounds, write or call our Alkyd sales department.

PLASTICS AND COAL CHEMICALS DIVISION
40 Rector Street, New York 6, N. Y.

OHIO RUBBER

"CUSTOMEERED COMPONENTS BASIC TO INDUSTRY"

Wide range of parts includes (top, left to right): valve stem deflector, condenser seal, (bottom) seal piston rod packing, universal joint seal, and oil seal. These vary in dimensions up to 1½" in diameter and 1" in thickness.

NEW! Precision rubber parts continuously molded in high volume . . . at lower cost

Precise tolerances within ±0.003 in. are now possible in large volume production of custom-molded rubber component parts. Ohio Rubber's new high-speed, continuous molding process produces such parts at rates of up to 200,000 pieces per day.

Greater precision, which results in important savings on finishing costs, is assured through use of single-cavity, self-registering molds. They permit accurate, uniform application of pressure to minimize flash—maintain consistent tolerances for all dimensions. Uniform material thickness is equally assured by a plasticizing mill, which as an integrated part of the process directs uniform charges to each mold.

Direct feeding, from the mill to the mold wheel, eliminates the conventional intermediate extrusion step and further insures part uniformity and quality consistent with specifications. The continuous process permits *precise* control of time and temperature for each part.

Large volume production results in substantial cost savings for small, precision parts requiring tolerances obtainable by other precision molding processes. For parts formed by less precise, conventional methods, performance can be improved through greater accuracy—and without prohibitive increase in cost.

Quantity requirements involving 500,000 or more parts annually are recommended for most advantageous use of the new process. Since two similar parts of different size can be produced simultaneously by alternating the molds on the molding wheel, lower production runs which might not be economical can be combined with a separate order.

Complete information on this revolutionary new process is available in bulletin form. Send for your free copy today. At the same time, be sure to inquire about Ohio Rubber's complete component "Customeering" service—molding, extruding, and bonding-to-metal. Just mention ORCO Bulletin 715.

DE-260

ORCO **THE OHIO RUBBER COMPANY**

General Office • WILLOUGHBY, OHIO • WHitehall 2-0500

A DIVISION OF THE EAGLE PICHER COMPANY

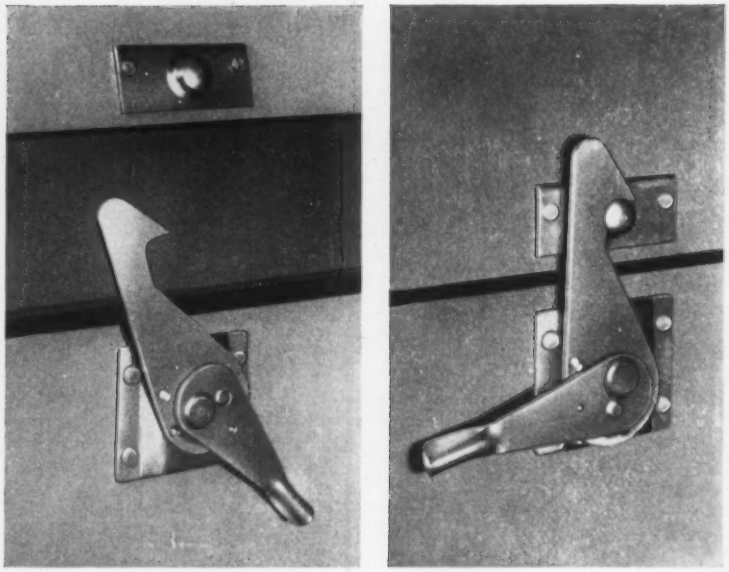
EAGLE EP PICHER

For more information, circle No. 323

For more information, turn to Reader Service card, circle No. 430

WHAT HOOK-LOCK IS

HOOK-LOCK is a springless, positive-locking latching device which is ideally suited for use on rigidly specified military transit cases as well as less expensive commercial containers. It provides high closing pressure and tremendous load-carrying capacity...is impact and shock-proof. HOOK-LOCK is so designed that it lies flat against the mounting surface whether in open or closed position. Since operation is parallel to mounting surface, no space for operating clearance is required.

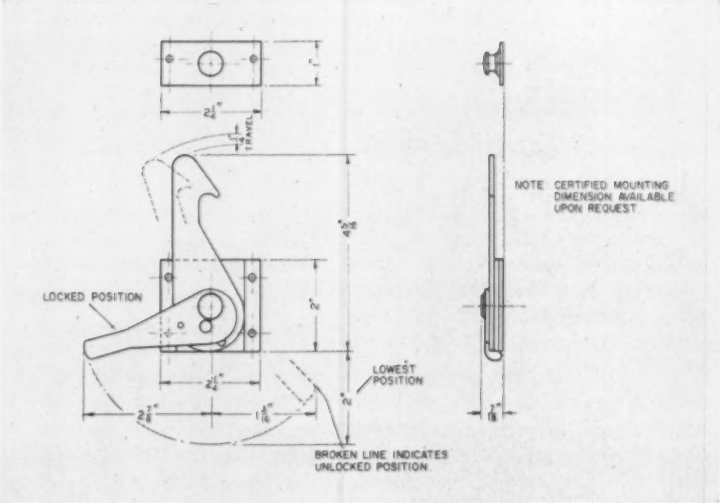


HOOK-LOCK lies flat against mounting surface, open or closed.

New—HOOK-LOCK container latch...It's flat!

FEATURES

- Shock-proof—solid construction...withstands high impact blows *directly on the fastener.*
- Closing pressure of 200 lb. Where needed, pull-down pressure can be substantially increased by modification of operating lever.
- Tensile load capacity: 750 lb.
- Compact—lies flat open or closed. Extends just 7/16" from container surface at thickest point.
- Positive-locking and springless. Unaffected by arctic temperatures.
- No operating clearance required, because hook and lever move parallel to mounting surface.


LOCKED POSITION
LOWEST POSITION
NOTE: CERTIFIED MOUNTING DIMENSION AVAILABLE UPON REQUEST
BROKEN LINE INDICATES UNLOCKED POSITION.

IF YOU have questions regarding the possible application of HOOK-LOCK or other Simmons industrial fasteners to your particular needs, your inquiry will receive our immediate attention. Contact your nearest Simmons office or write direct.

SIMMONS FASTENER CORPORATION

1759 North Broadway, Albany 1, New York

See our 8-page catalog in Sweet's Product Design File

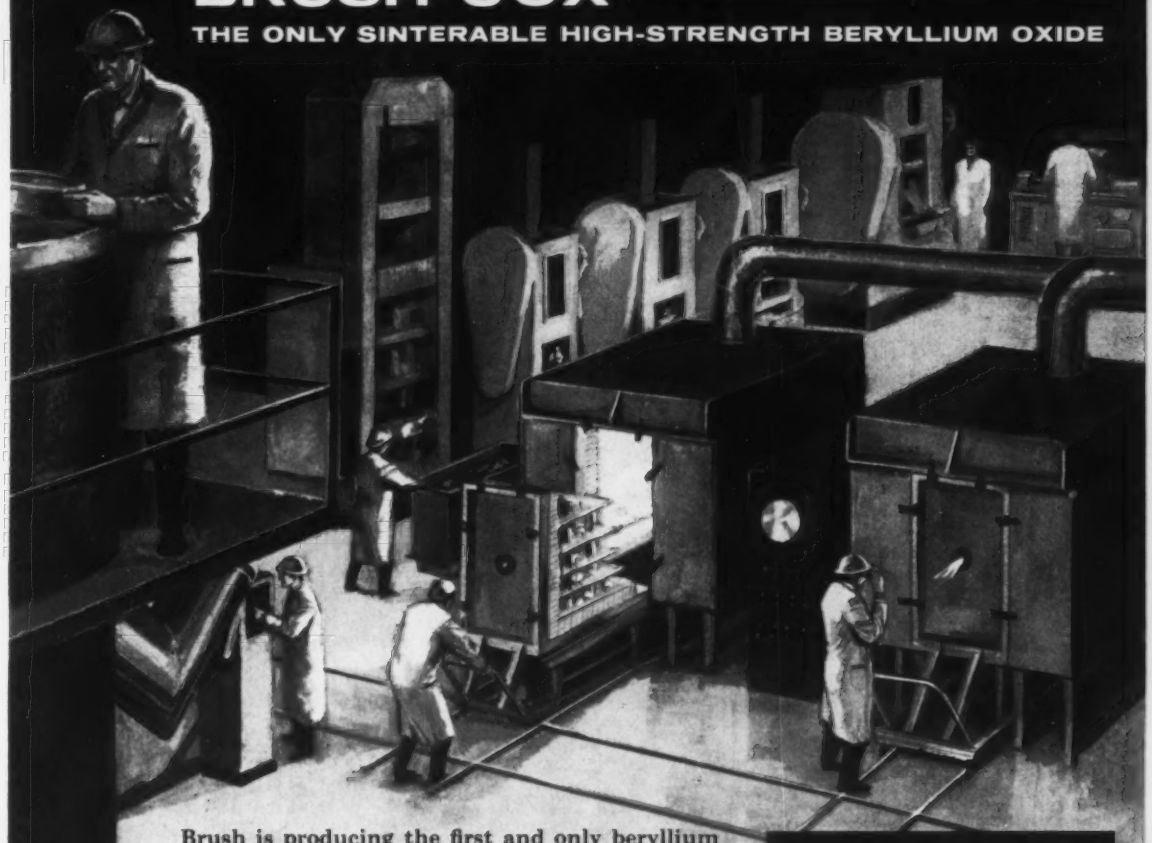
For more information, turn to Reader Service card, circle No. 461

SIGNIFICANT ADVANCES IN BERYLLIUM TECHNOLOGY COME FIRST FROM BRUSH

A MATERIAL FIRST

BRUSH UOX®

THE ONLY SINTERABLE HIGH-STRENGTH BERYLLIUM OXIDE



Brush is producing the first and only beryllium oxide that is both sinterable and 99.95+% pure. This combination means that manufacturers of nuclear, electronic, and aero/space components can now mass produce ceramics taking full advantage of beryllium oxide's remarkable properties.

BeO is an excellent reflector and moderator of neutrons. Its unique thermal properties include room temperature conductivity superior to most metals. It has good strength, a melting point of 4658° F., and is inert to chemical attack.

More detailed information on versatile UOX® is yours for the asking. Contact us at ENdicott 1-5400 or 5209 Euclid Avenue in Cleveland, Ohio, and we will show you how beryllium oxide can fit into your requirements for high-performance ceramic components.

Any shape that can be fabricated by standard ceramic production methods can be produced in UOX® beryllium oxide.

THE BRUSH BERYLLIUM COMPANY

For more information, turn to Reader Service card, circle No. 492

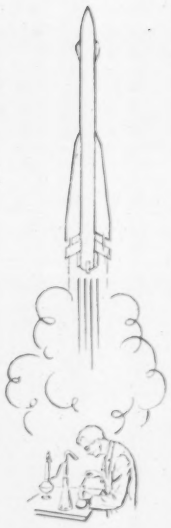
V-R Metals...

when CORROSION strikes...

Metals of tomorrow ...TODAY!

Vascoloy-Ramet, pioneering manufacturer of refractory metals, is making a substantial contribution to today's advancing metallic age. V-R is creating and developing special metals with exceptional characteristics to meet the ever-changing demands of industry. Thirty years of V-R research, engineering, and manufacturing experience have produced the metallurgical knowledge built into all V-R products. This same experience and knowledge is working full time to meet the needs of tomorrow.

A-798



Vascoloy-Ramet creates metals that are impervious to corrosion. V-R also creates metals that possess amazing stability at extreme temperatures, high rigidity under load, extremely low coefficients of expansion, ultra-high density and controlled uniformity.

Yes, many of today's metal requirements are met by Vascoloy-Ramet. V-R designs these sintered and alloyed materials to fill your metal requirements. Many engineers are utilizing V-R assistance for metal design assurance.

For additional information, contact V-R today.

V-R

CREATING THE METALS THAT SHAPE THE FUTURE

VASCOLOY-RAMET

858 MARKET STREET • WAUKEGAN, ILLINOIS

For more information, turn to Reader Service card, circle No. 528

The redesign of this forging solved a machining problem

BEFORE: Forged on an upsetter, this cylinder presented minor machining problems for the customer. The forging had to be trimmed on the sides; this resulted in flat spots, uneven cuts. It was also difficult to keep the OD concentric with the bore.

AFTER: Made on a mechanical press, this cylinder offers a better surface for machining. Sides don't have to be trimmed, so there are no flat spots, no uneven cuts to worry about. No gripping collar, either. Concentricity of OD and bore is excellent.

Steel

for Strength
. . . Economy
. . . Versatility

In this case a mechanical press produced a better piece for the customer than an upsetter. But we know many cases where the opposite is true. One of the nice things about doing business with Bethlehem is knowing we'll recommend the one "right" method of manufacture the first time around. We have the experience, and the facilities (press, hammer, drop, and upsetter) to back up our recommendations. A chat with one of our design engineers costs you nothing . . . and may help to turn your problem into a profit. Our nearest sales office can arrange a meeting to suit you.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.
Export Distributor:
Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

For more information, turn to Reader Service card, circle No. 337

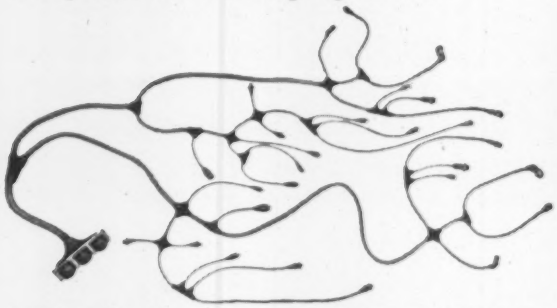
General Electric RTV* liquid silicone rubber

*Room Temperature Vulcanizing

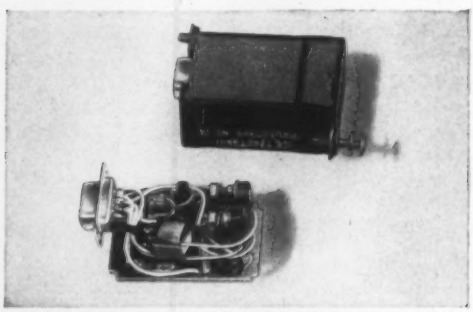
New low viscosity for easier encapsulation and impregnation

The latest addition to General Electric's RTV family offers lower viscosity than any other available silicone rubber compound — a typical viscosity of 120 poises. Easily pourable, it flows freely in and around intricate contours, making it ideal for protecting electrical and electronic components.

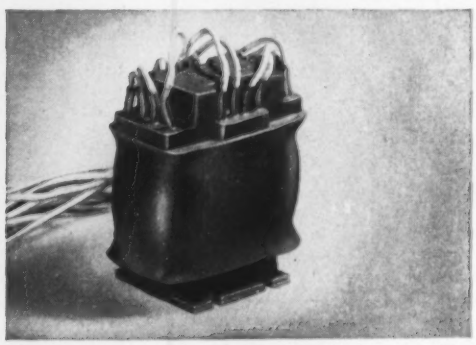
With RTV's new low viscosity, the range of G-E RTV compounds now extends from 120 to 12,000 poises. You can now meet your specific requirements by selecting from several G-E RTV compounds, all of which offer room temperature cure, heat and ozone resistance, and good electrical properties. Write for a free test sample, briefly describing your application.



General Electric silicone rubber used extensively by Aerojet-General Corp. for the Titan ICBM's propulsion-system wiring harness. Breakouts and junctions molded from G-E RTV, wiring is silicone insulated, jacketing is high-strength G-E silicone rubber — all chosen for their stable insulating properties, resistance to temperature extremes and weathering, and stability in storage for many years.



Sight amplifier module potted with RTV by the Armament and Control Section of G.E.'s Light Military Electronics Department. Used on the Lockheed CF-104 and F-104G jet aircraft, RTV provides mechanical support and vibration damping, protects unit against moisture and ozone. (Bottom photo shows module before potting.)



High-voltage, high-altitude transformers from Laboratory For Electronics, Inc. are encapsulated with General Electric RTV to meet MIL-T-27A specs. This prevents flashover at maximum ratings of 2200 volts rms and 80,000 feet. General Electric RTV was selected for its good heat transfer, low viscosity and mechanical strength.

GENERAL ELECTRIC

Silicone Products Department, Waterford, New York

For more information, turn to Reader Service card, circle No. 512

THIS IS GLASS

A BULLETIN OF PRACTICAL NEW IDEAS FROM CORNING

NO PLACE FOR AN ACROPHOBE

When first we read of the seven who are eager to blaze a route to the stars, we pondered what we thought of as man's inborn fear of great heights.

Now we learn that the first of the astronauts will have a window in his capsule, that he will peer *down* at the spinning earth and *out* at the wheeling stars.

We are producing these unique, space-going viewports for McDonnell Aircraft Corporation, prime contractor for the National Aeronautics and Space Administration's Project Mercury capsule.

The window is an excellent piece of engineering. Not just because we made it, but because it *has* to be.

It will take the slams and whams, the blistering heat, and the embrittling cold of blast-off, orbitation, re-entry, and a soak in the briny. All during this it must remain transparent, intact, and sealed tight.

There are four panes to the window. The outer two are VYCOR® 96% silica glass. The inner two are aluminosilicate glass specially tempered to phenomenal strength.

Each pane is ground and polished to the precision finish of a telescope mirror. The outermost panel curves to the contour of the capsule, so it trapezoids from an 11″ base to a 7½″ top along a 21″ height.

The glasses present a delicate balance of optical qualities, thermal shock resistance, and low weight. The last is vital when you consider that it takes about 100 gm of fuel to orbit 1 gm of payload.

So, remember, when you see the first astronaut smiling quietly, confidently from his capsule, you are looking at him through Corning glass.

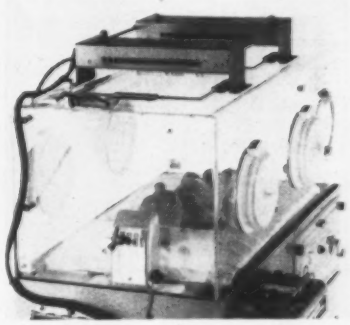
HOW ABOUT A DEGREE IN MEDICAL ENGINEERING?

The mechanics of modern medicine are fast maturing to the point where some engineers are specializing in the building of machines like this Infant Servo-Controller for the Isolette, manufactured by Air-Shields, Inc., Hatboro, Pennsylvania.

This particular machine is used with prematurely born infants who must keep their body temperature at a constant level, but lack a well-developed thermal regulatory device.

You attach a thermistor to the babe's abdomen and let him work as his own thermostat. He automatically requests heat from infrared lamps whenever his skin temperature drops below 97°F. When things are just right again, he switches off the lamps and takes a rest, with the odds for survival more in his favor.

If you've ever tried to unbulb an infrared lamp, you know that it gives off *direct* heat as well as IR energy.

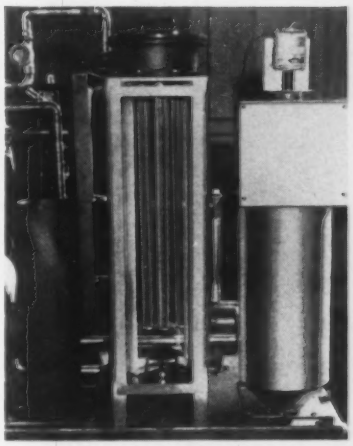


That's why there are two PYREX No. 7740 glass plates sitting on top of the plastic chamber in the picture. You can see them, if you look closely. The PYREX plates are heat resistant and will also dissipate the *direct* thermal output of the lamps. So, the plastic forgets the lamps are there.

As far as the IR energy is concerned, the PYREX plates don't exist either, so practically all the IR gets through to the baby.

The over-all relationship between IR and glass is an odd one. We can give you glass which transmits as much as 92% of the IR or a glass which transmits as little as 8% of the IR.

Happily for our product specialists, there is demand for both situations. We've prepared some bulletins on many of these IR characteristics, a copy of which you may have by sending the coupon.



SOMETIMES GLASS IS SO OBVIOUS

Leafing our way through the 4th Annual Shirt Issue of "Cleaning Laundry World" (April 1960), we took note of an advertisement which concerned a machine which displayed a feature which we consider the soul of genius.

The machine is a dry cleaner manufactured by Detrex Chemical Industries, Inc. The feature is a glass-enclosed filter which keeps the dry-cleaning solvent cycling unpolluted. The soul of genius, to our minds, consists of intelligent manipulation of the obvious . . . in this case, an application of the first known and longest respected of the myriad properties of glass . . . to wit, its *transparency*.

When you locate such a place, it doesn't necessarily take a lot of redesigning of custom fabrication to put glass to work, either. We checked and found that Detrex, for example, simply orders standard 6″ O.D. PYREX brand Heavy Duty Tube for its filter wall.

The result is that the operator of the Detrex Cleaner can watch the filter at work. He can spot trouble while it's still potential, determine its cause exactly should it occur . . . all without any dismantling or shutdown.

Is there anything you're working on that you wish you could watch working? If there is, and you want to put glass to work, you can start by sending the coupon for a copy of Bulletin IZ-1, "Designing with Glass for Industrial, Commercial, and Consumer Applications."

CORNING MEANS RESEARCH IN GLASS

CORNING GLASS WORKS, 50 Crystal St., Corning, N. Y.

☐ IR Transmitting Glasses ☐ IR Reflecting Glass ☐ IZ-1

Name..... Title.....

Company.....

Street.....

City..... Zone..... State.....

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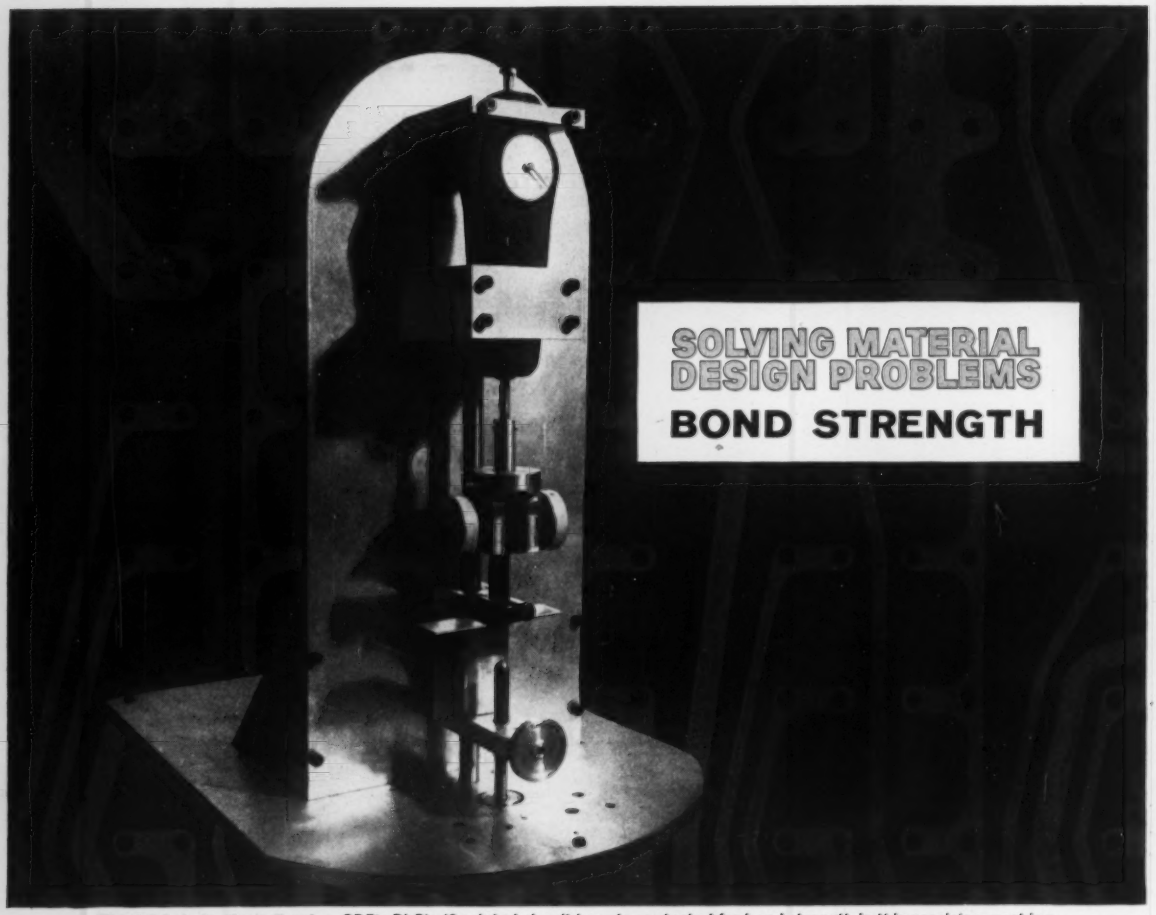


The trick is in the adhesive. CDF's Di-Clad® printed circuit boards are tested for bond strength in this precision machine.

CDF has developed special adhesives for bonding copper foil to laminated plastic boards. These adhesives produce high peel strength, have excellent hot solder resistance, etch cleanly, and provide high insulation resistance.

In addition to its own adhesives, CDF makes resins and papers. This extends quality control several steps beyond simple pressing operations . . . provides you with Di-Clad boards of excellent and uniform properties.

CDF manufactures the largest selection of grades to meet every major civilian and military requirement.

In addition to Di-Clad printed circuit boards, CDF has special combination materials to solve extra troublesome problems. Example: asbestos bonded vulcanized fibre for circuit breaker arc chutes where the fibre quenches the arc and the asbestos guarantees fire resistance.

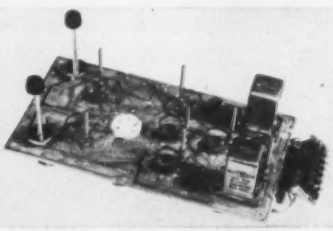
If you don't see the grade you want in CDF's catalog in Sweet's PD file, write us.

CONTINENTAL-DIAMOND FIBRE

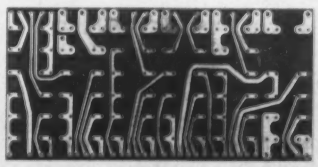
A SUBSIDIARY OF THE Bradley COMPANY • NEWARK 25, DEL.

In Canada, 46 Hollinger Road, Toronto 16, Ont.

Vibration-free plug bases, fabricated by CDF. A special bond of CDF Dilecto laminated plastic and rubber.



High reliability printed circuits for military applications. Made from CDF's glass-base Di-Clad laminated plastic.



Low-Cost commercial circuits. Made from CDF's paper-based Di-Clad copper-clad laminate.

For more information, turn to Reader Service card, circle No. 522

Tulip bed for stainless...

In our Viaduct Plant shear bay this "tulip bed for stainless" is important to you. It is this ball-bearing bed that helps our shearmen position plate easily, quickly, efficiently. But there's more than speed shown here. Carlson engineers modified this modern shear to provide unusually accurate cutting of stainless plate to your specifications.

Equipment of this type, coupled with our thorough knowledge of stainless steel, brings you the finest products . . . the finest service. For almost a quarter of a century it has been our aim to serve you best by producing what you want and delivering it on time.

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A new family of materials to meet special problems

•

SHOCK
STRESS
ABRASION

AMSCO® ALLOYS

In addition to austenitic manganese steel castings—long known for their exceptional service life in mining, construction, quarrying and milling applications—Amsco now offers *seven* other ferrous alloy materials. These include specially alloyed manganese steels, chrome moly steels, high strength alloyed steels and alloyed cast irons.

Each has particular advantages for specific service requirements, involving various combinations of impact, stress and wear. Check the brief facts on these alloys below. Then call in an Amsco sales engineer to assist in selecting the *one best* material to meet your application needs.

AMSCO ALLOY DESIGNATION	DESCRIPTION AND USES	MECHANICAL PROPERTIES
MY	Heat-treated, chromium alloyed manganese steel ... for use in light-to-medium weight castings requiring modest improvement in growth and distortion, and increased stiffness.	tensile strength ..... 120,000 psi yield strength ..... 56,000 psi elongation ..... 45% reduction of area 30%
MML	Heat-treated, molybdenum alloyed manganese steel ... for castings requiring improved weldability, for extremely heavy metal sections, and castings exposed to excessive heating environments.	tensile strength ..... 120,000 psi yield strength ..... 52,000 psi elongation ..... 50% reduction of area 40%
MMH	Heat-treated, molybdenum alloyed manganese steel ... for use in castings requiring optimum mechanical properties and wear resistance. Provides improved stiffness and resistance to peening and flow.	tensile strength ..... 120,000 psi yield strength ..... 65,000 psi elongation ..... 20% reduction of area 18%
CML	Heat-treated, air-hardening chrome-moly steel ... for casting applications involving scouring or grinding wear. Suitable for more complex casting designs.	tensile strength ..... 155,000 psi yield strength ..... 130,000 psi elongation ..... 10% reduction of area ..... 15% hardness ..... 275-375 BHN
CMH	Heat-treated, air-hardening chrome-moly steel ... exhibits potentially improved wear resistance over CML (above), when shock loading is not sufficiently severe to cause breakage.	tensile strength ..... 155,000 psi yield strength ..... 130,000 psi elongation ..... 6% reduction of area ..... 7% hardness ..... 300-400 BHN
CS	Martensitic, multiple alloy steel with chromium, nickel and molybdenum ... combines high mechanical strength with good abrasion and wear resistance.	tensile strength ..... 220,000 psi yield strength ..... 195,000 psi elongation ..... 8% reduction of area ..... 20% hardness ..... 300-500 BHN
HC	High chromium cast iron ... provides outstanding abrasive wear resistance, where impact force is low but particle velocity and scouring forces are high.	tensile strength ..... 60,000 psi transverse strength ..... 7,000 lbs. deflection ..... 0.12 in. hardness ..... 400-600 BHN

For further information —write for technical bulletin on "Amsco Ferrous Alloy Castings".

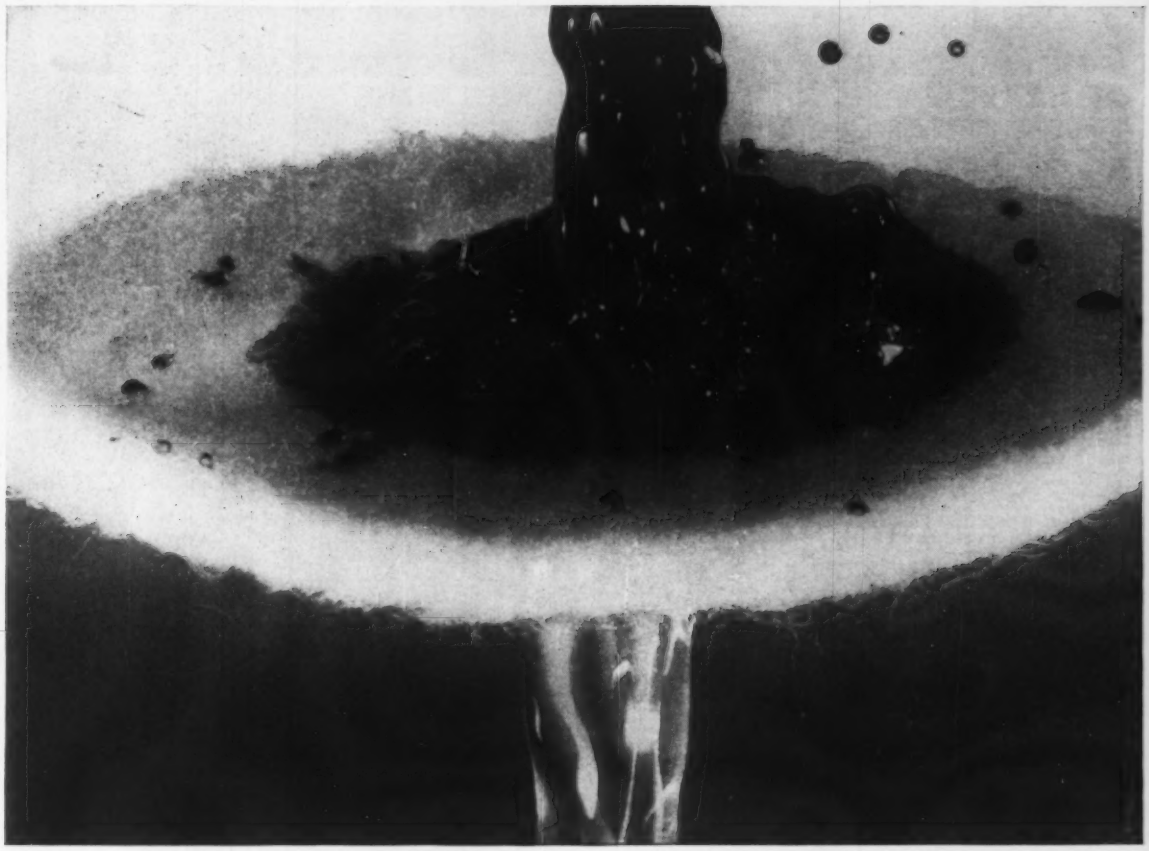
AMERICAN Brake Shoe COMPANY

AMSCO

American Manganese Steel Division • Chicago Heights, Illinois

For more information, turn to Reader Service card, circle No. 328

An example of Avisco Rayons in Industry



Why rayon fibers are rapidly gaining in filtration applications

Avisco rayon fibers have been making giant strides in filters for smoke, air and liquid filtration. Why? Because they can be engineered to meet specific filtration needs . . . plus low cost and filtration control.

Avisco rayon can be produced in accurate diameters resulting in controlled micron ratings economically unapproached by other fibers.

American Viscose makes the fibers, not the filters. If you make or use filters, it will pay you to investigate Avisco fibers for more accurate, more economical filtration. *Just fill in the Quick Reply Coupon.*

QUICK REPLY COUPON 1-4

American Viscose Corporation
350 Fifth Avenue, New York 1, N.Y.

Please contact me about Avisco Fibers for filtration use in

_____

Name_____

Company name_____

Address_____

City_____ Zone____ State_____

AVISCO® RAYON

AMERICAN VISCOSE CORPORATION, 350 Fifth Avenue, New York 1, N. Y.

For more information, turn to Reader Service card, circle No. 526

Two new additions to The REINHOLD PLASTICS APPLICATIONS SERIES

1 METALLIZING OF PLASTICS

by HAROLD NARCUS

President and Technical Director
Electrochemical Industries, Inc.
Worcester, Massachusetts

1960, 208 pages, $5.50

THIS BOOK presents complete details for carrying out every commercial metallizing process for plastics or other nonconductors. It is the first treatment of the subject to deal with actual production procedures, formulations and techniques for all known metallizing methods. Among the topics discussed are the copper film process (developed by the author), the deposition of electroless nickel coating, a review of the new molded conductive plastics, "gas" plating, and the deposition of thick evaporated films. The author includes numerous illustrations showing the latest equipment being used in the newer processes. Much more than a bibliographic source, this book is essentially a metallizing manual for the plastics, electronics and electroplating industries.

CONTENTS: Introduction; Deposition of Metallic Coatings by Chemical Reduction; Vacuum Metallizing (Metal Evaporation); Cathode-Sputtering Process; Silver-Spray Methods; Electrodeposition; Miscellaneous Metallizing Methods; Characteristics and Testing of Metallic Deposits on Plastics; Recent Developments and Future Potential Uses for Metallized Plastics; Bibliography; Index.

2 RUNNERLESS MOLDING

by ERNEST P. MOSLO

President,
Moslo Machinery Company

1960, 179 pages, $4.95

DESCRIBES IN DETAIL the methods of injection molding accomplished without the removal of a sprue and runner system on each molding shot. The book's purpose is to show ways of further economies to the plastics and related industries insofar as the molding process and molding equipment are concerned. A wealth of explanatory drawings shows the actual construction of nozzles used for runnerless molding, manifolds and mold equipment.

CONTENTS: Introduction to Runnerless Molding; Materials and Automatic Molding Machines for Runnerless Molding; The Beginning of Runnerless Molding; A Practical Runnerless Mold Design; Nozzle Design Variations for Runnerless Molds; Manifold and Multiple Runner Arrangement; Large Section Runnerless Molding; Valve Gating for Precompressed Molding; Sequential Impact Molding; An Insulated Runner System for Injection Molding.

and

3 ACRYLIC RESINS
by MILTON B. HORN, *Catalin Corporation of America*
1960, 192 pages, $4.50

4 POLYESTER RESINS
by JOHN R. LAWRENCE, *The Glidden Company*
1960, 256 pages, $5.75

5 AMINO RESINS
by JOHN F. BLAIS, *Chemical Consultant*
1959, 232 pages, $4.95

6 PHENOLIC RESINS
by DAVID F. GOULD, *Consultant to the Borden Chemical Company*
1959, 272 pages, $5.75

7 SILICONES
by ROBERT N. MEALS, *Manager, Chemicals and Chemical Process Unit* and FREDERICK M. LEWIS, *Manager, Advance, Development Silicone Products Dept., General Electric Company*
1959, 280 pages, $5.95

8 LAMINATED PLASTICS
by D. J. DUFFIN, *Editorial Consultant, Continental-Diamond Fibre Corporation*
1958, 264 pages, $5.75

9 GUM PLASTICS
by M. S. THOMPSON, *Naugatuck Chemical Division, U.S. Rubber Company*
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10 VINYL RESINS
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by MERRITT A. RUDNER, *Enflo Corporation*
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by DON E. FLOYD, *General Mills, Inc.*
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by ROBERT L. BUTZKO, *The Auto-Vac Company*
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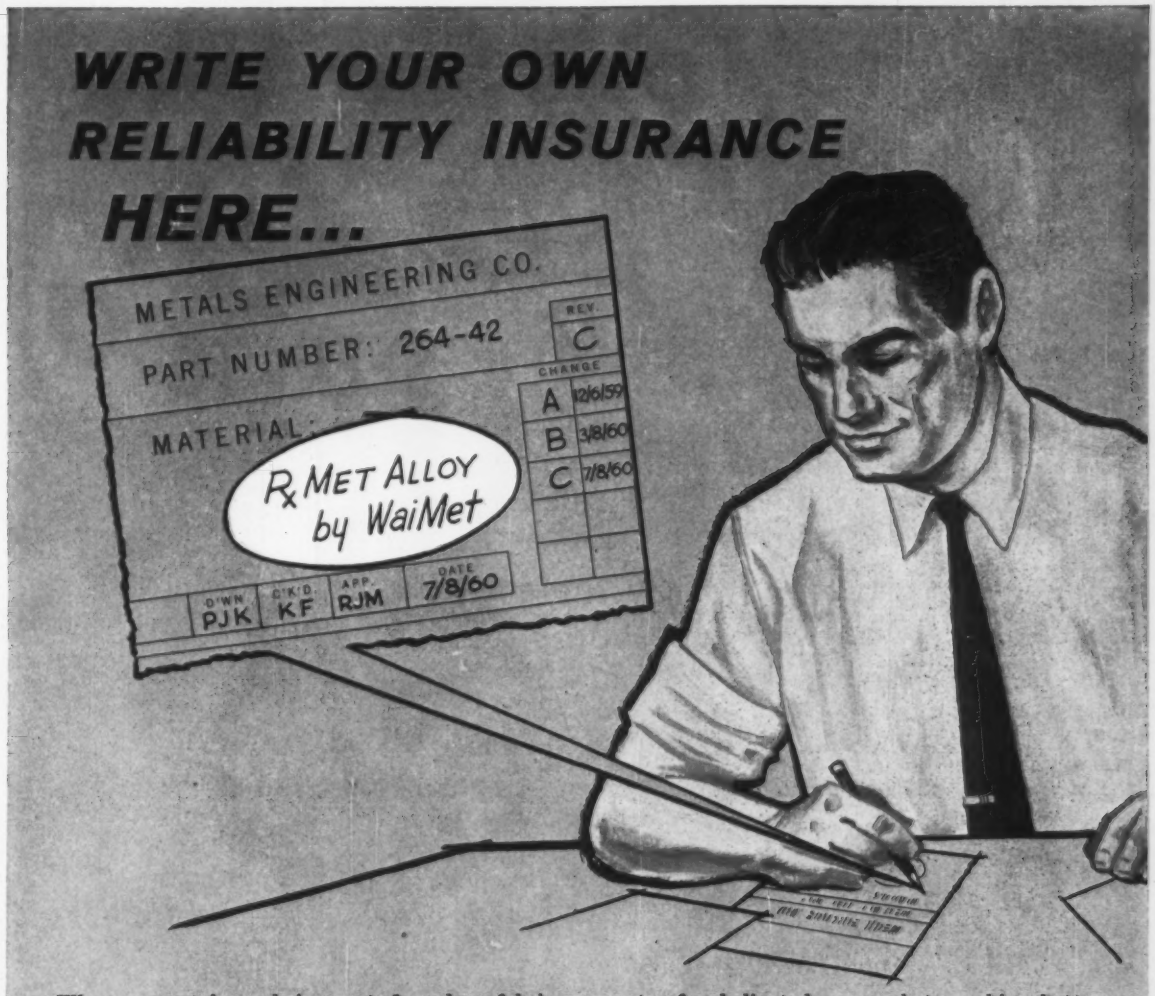

Wherever metals are being cast, forged, or fabricated, the important factor of reliability can be assured by specifying R_xMet brand alloys. Whether we ship shot for making castings, billets for forging, or special welding rod, the R_xMet label on the alloy means more consistent performance in the finished product.

At WaiMet, metallurgical reliability and quality control are more than words—they are integral parts of a dedicated approach to making better alloys. We dig a little deeper than most to find out why an alloy behaves as it does, then define new limits of chemistry to guide the production of every heat. Result: alloys with reproducible, consistently better mechanical properties.

In almost every alloy we make there is some WaiMet improvement in processing or heat treatment technology that will mean better reliability insurance for the user.

HERE ARE TYPICAL REASONS WHY ALLOY USERS SPECIFY R_x MET®

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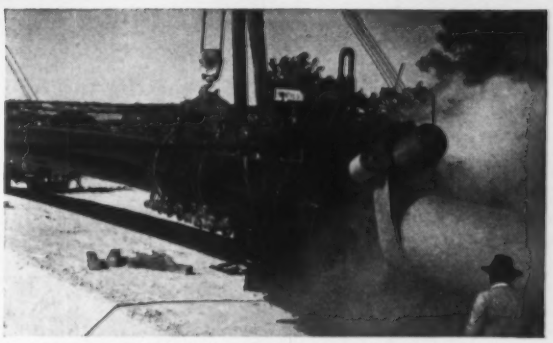

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by GEORGE F. HAWLEY, *Vice President of Development and Engineering, Automation Engineering Laboratories, Inc.*

1959, 176 pages, $4.95

THE EMINENTLY sound ideas which this book presents merit the attention of all concerned with the use and development of special automatic machinery. It presents in practical terms some of the mechanical problems involved in developing automatic equipment for specific operations, such as assembly of components, packaging of individual products, bottle capping, feeding, etc. Management and production personnel will gain a greater appreciation for the problems encountered in developing successful machines, while designers and development engineers will find a machine development procedure which, if followed, should minimize their failures.

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2 VACUUM PROCESSING IN METALWORKING

by J. WESLEY CABLE, *Consulting Engineer*

1960, 256 pages, $5.50

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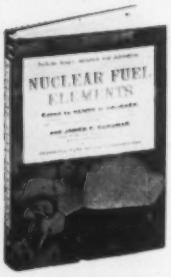
3 NUCLEAR FUEL ELEMENTS

edited by HENRY H. HAUSNER, *Adjunct Professor, Brooklyn Polytechnic Institute and* JAMES F. SCHUMAR, *Associate Director, Metallurgy Division, Argonne National Laboratory*

1959, 432 pages, $12.50



CONTAINS the papers presented at the First International Symposium on Nuclear Fuel Elements held at Columbia University in January 1959. This book is the first to deal exclusively with the nuclear fuel elements. The twenty chapters include first-hand information from scientists in the U.S. and European countries who have worked on the development, design and fabrication of fuel elements. These scientists describe their own experiences. Among the individual topics presented by each chapter are discussions of the use of the fuel elements for reactors of the future, the standardization of certain types of elements, cost analysis for low-cost fabrication and reprocessing, metallic fuel elements made from uranium, thorium and plutonium, dispersion-type fuel elements, high-temperature fuel elements, and the behavior of fuel elements under reactor operating conditions.

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4 MATERIALS AND TECHNIQUES FOR ELECTRON TUBES

by WALTER H. KOHL, *Senior Engineering Staff, Sylvania Electric Products, Inc., a Division of General Telephone & Electronics Corporation, General Telephone & Electronics Corporation Technical Series*

1960, 640 pages, $16.50

HERE IS the completely revised edition of the previous "Materials Technology for Electron Tubes," long known as the standard work on the subject in English. The text has been rewritten and reorganized on the basis of replies to a questionnaire submitted to a large number of competent users of the first edition. As a result, the text has been brought thoroughly up-to-date. The book covers all the material components of electron tubes and the methods of uniting them, such as joining of metals by brazing, glass-to-metal sealing, and ceramic-to-metal sealing. Chapters dealing with specific materials contain extensive tabulations of physical characteristics, chemical reactions with various reagents, and processes used in application.

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6 POLYESTER RESINS

by JOHN R. LAWRENCE, *Project Coordinator—Glidpol Resin, The Glidden Company*

1960, 256 pages, $5.75

HERE IS a comprehensive presentation of the unsaturated polyester resin industry. It covers all aspects from historic background, chemistry, curing mechanisms and manufacturing to techniques used in processing the resins for use in reinforced plastics, casting and coating applications. Particular emphasis is given to formulating resins for special properties such as weathering and flame resistance. The chapter on coating applications is the most complete coverage ever published on this relatively new use for polyester resins.

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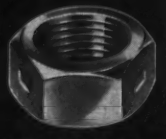

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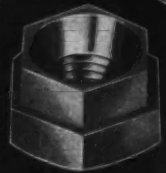

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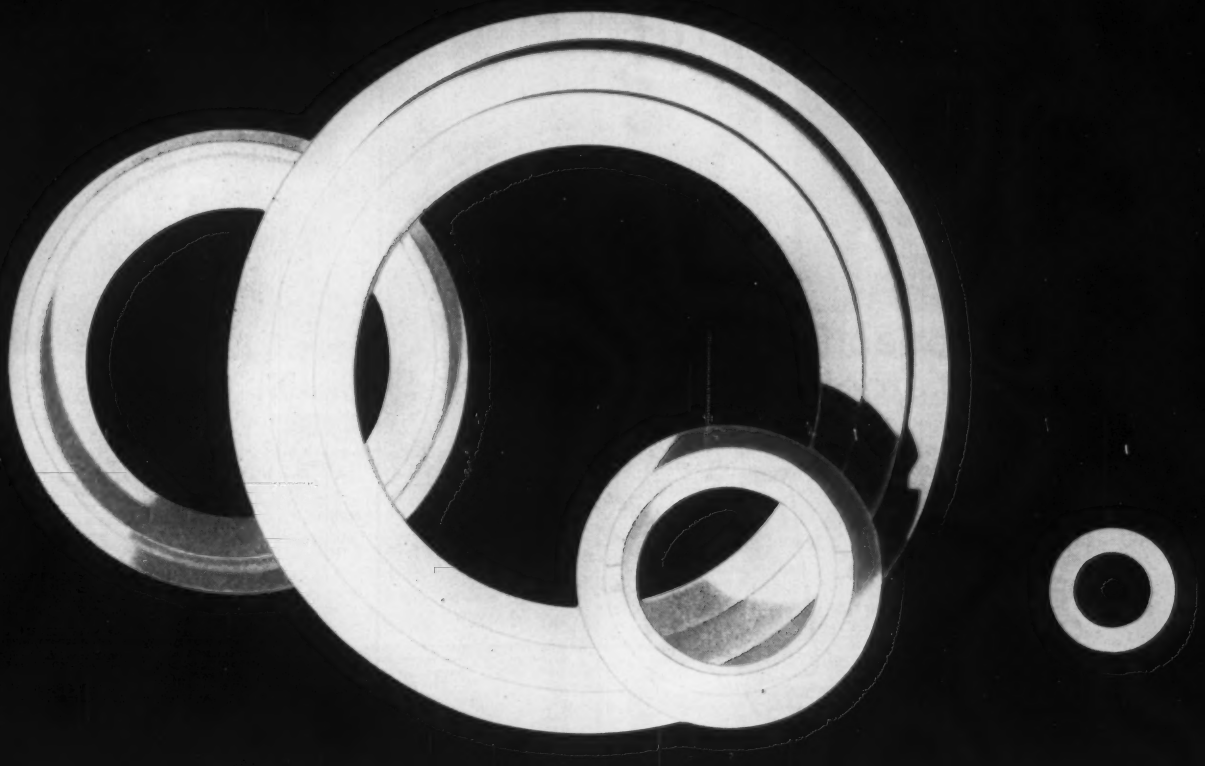

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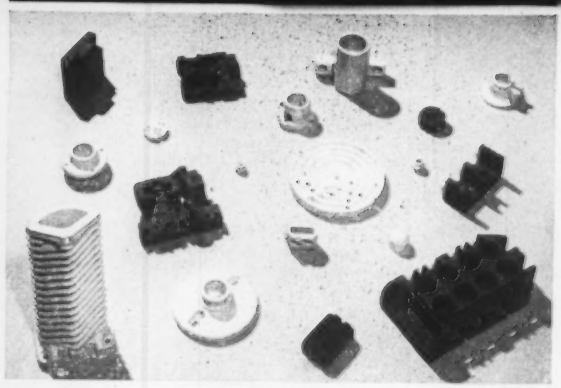

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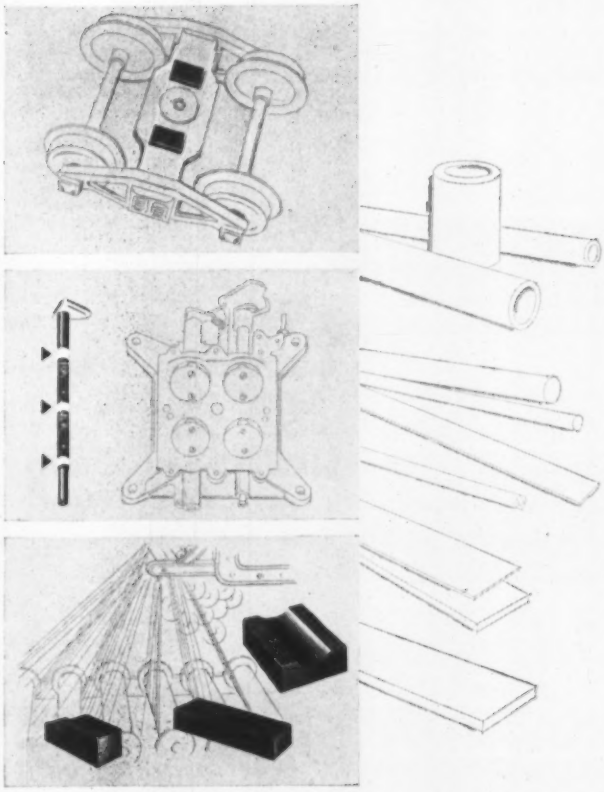

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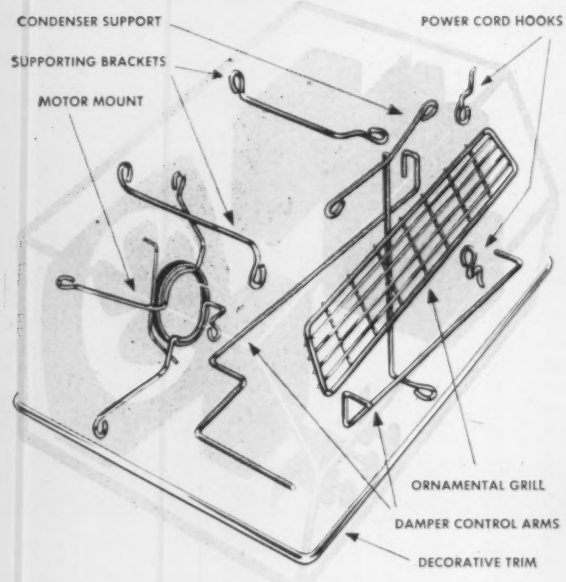

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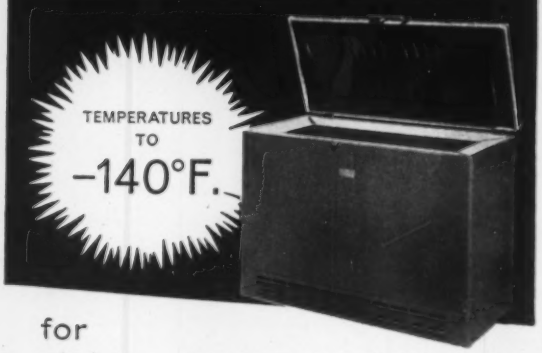

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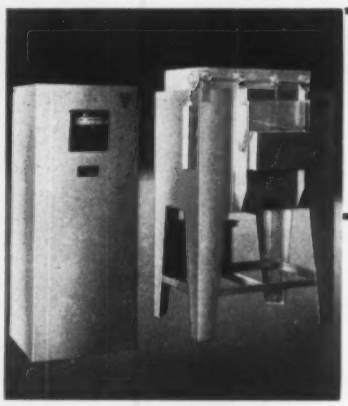

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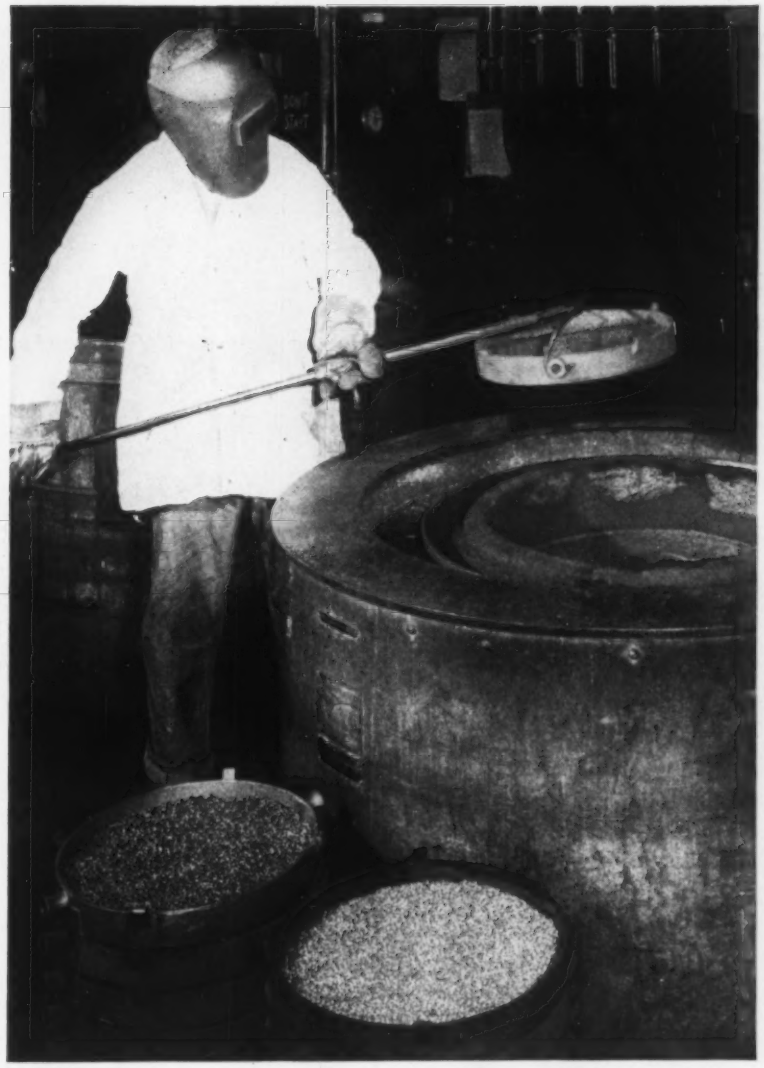

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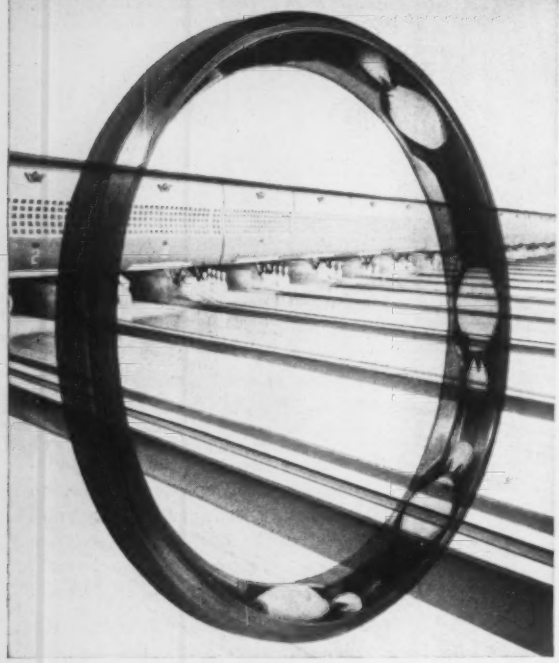

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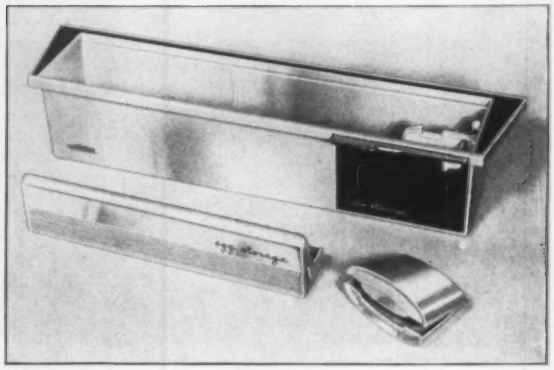

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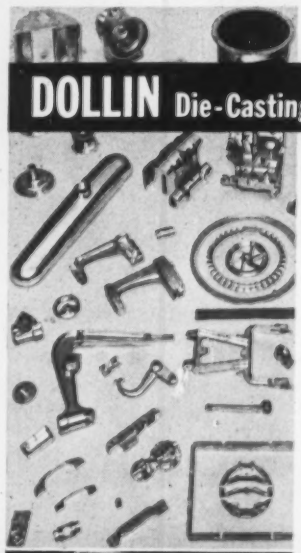

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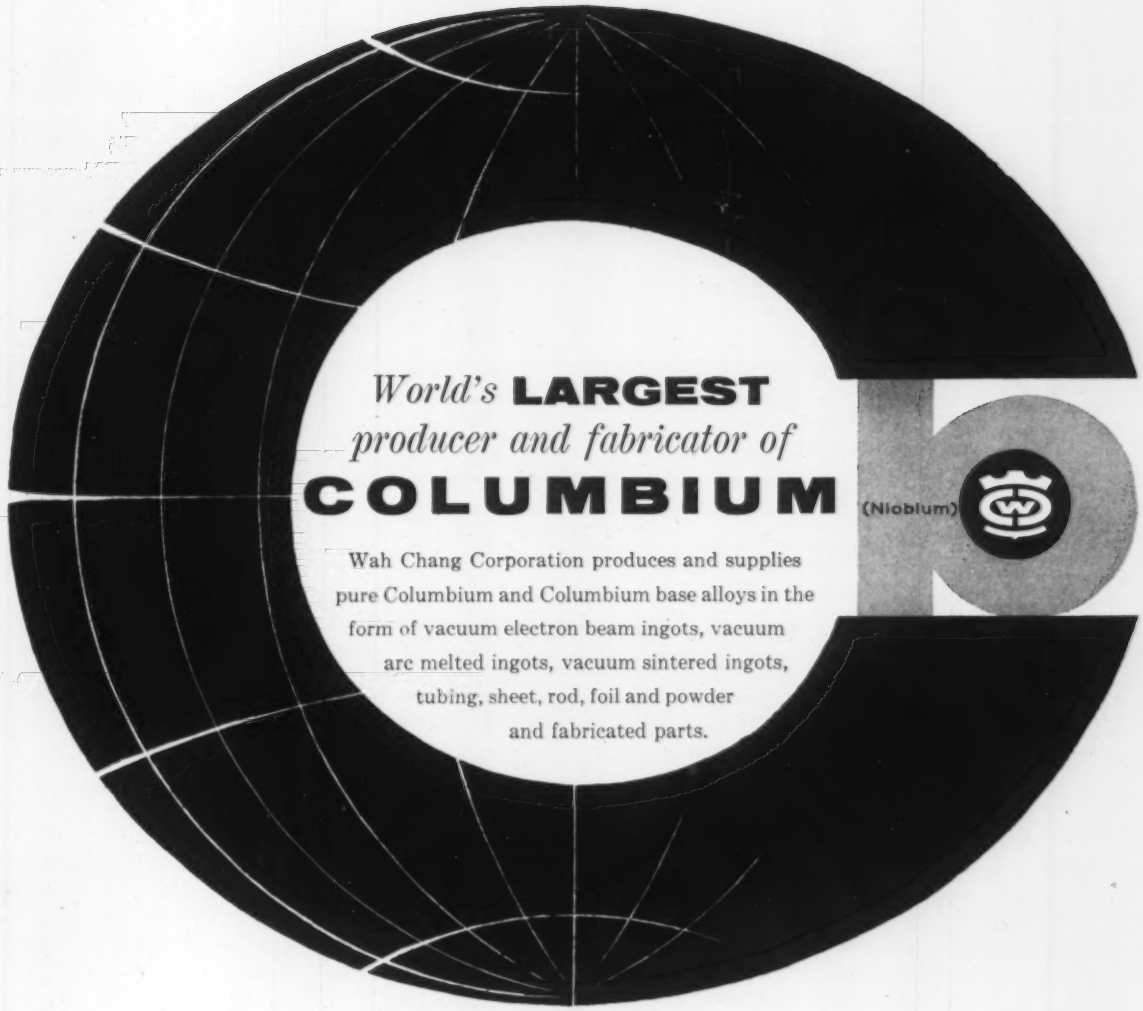

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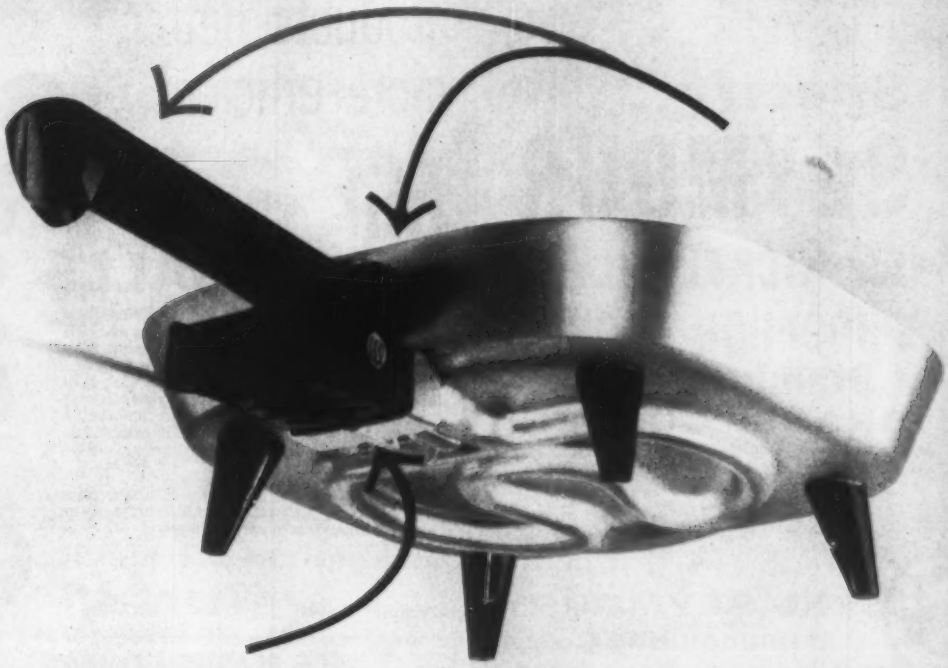

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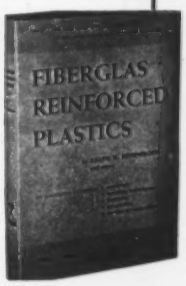

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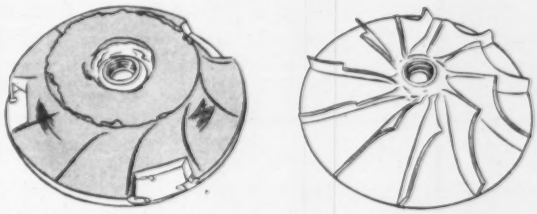

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THE LAST WORD

The Materials Age Is Here

Recently we read in *Reynolds Review* an article that appeared originally way back in 1892 in *Cosmopolitan* magazine. Entitled "Aluminum —the Metal of the Future," it was a remarkably accurate forecast on aluminum. Since then a number of other metals, such as magnesium, titanium and beryllium have been declared metals of the future and similar articles have been written.

But today we know that no one material, or even one group of materials, will have a monopoly in the future. The present and the future need all materials. And as the special "Materials Age" section in this issue clearly demonstrates, a new unified field of materials is emerging in which materials undreamed of today will be developed and used to meet the requirements of tomorrow.

Thus, a virtual revolution in materials technology is rapidly overtaking us. Our institutions —societies, education and industry—must take heed, and prepare and adapt to meet its challenge. What the challenge is and what these institutions are doing about it is the theme of this Materials Age issue. We hope you will read it thoughtfully.—HRC

Casting in the Bronze Age

Speaking of "ages," in doing our research for this special issue, we uncovered an interesting historical sidelight on the Bronze Age. From remains found in England it is quite certain that man had already learned how to make gravity castings in that ancient period. Mold cavities were shaped in stone and they were used extensively in the production of bronze axes, knives and swords. The molds were made by working two pieces of stone until they were thoroughly flattened. Holes were then drilled to position the dowel pins necessary to align the mold, and one-half of the cavity was carved in each stone face. Cores were in common use.

The ancient molders knew how to gate their work, and some of the stone molds that have been found contain as many as 12 cavities. They must also have encountered considerable trouble with entrapped air since some of the molds show vents large enough for metal to flow through. —DP

Fission, Space and Gold

Prior to Sputnik I, at least, science was a favorite whipping-boy for many well-meaning persons seeking a cause to which could be attributed all the evils around them. The advent of Hiroshima set off many debates which, pathetically enough, seemed to be concerned with the "evil" of atomic fission rather than the inhumanity of man. We can expect the exploration of space to be met eventually with similar logic. Confusion between causes and instruments probably results in more anguish today than in early times, but only because there are more instruments around to confuse us. Such confusion was certainly not unknown back in the early 16th century when Georgius Agricola in his *De Re Metallica* took note of the widespread condemnation of gold as a source of evil:

> "Might not anything we possess be called a scourge to human kind . . . Are we then not to ride on horses, but to journey on foot, because a robber has once committed a murder in order that he may steal a horse?"

Agricola worried the point considerably, as was and is the fashion in learned discourse, but concluded that "it is not metals to be condemned, but our vices, such as anger, cruelty, discord, passion for power, avarice and lust."—JBC

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